WHEN it is conſidered that the Small-Pox is one of the chief cauſes of depopulation, and that, in London alone, one hundred and ſeven thouſand one hundred and fifty perſons have been carried off by it within the laſt fifty years; Inoculation ſeems to have been providentially introduced, to diſarm the Natural Diſeaſe of its malignant power—to promote the encreaſe of mankind, ſecure the preſervation of individuals, and leſſen the ſum of human miſery.

When it is further conſidered, that ſcarcely one in five hundred die in the Inoculated Small-Pox, we cannot but lament over the loſs of thoſe one hundred and ſeven thouſand one hundred and fifty victims, moſt of whom might have been redeemed from the grave, and, by the probable encreaſe of their offspring, have made an immenſe addition to the ſtrength of the ſtate.

The means of counteracting the ravages of this fatal diſtemper by Inoculation, have been very generally embraced by the higher claſſes of people in this nation; but, to a very uſeful, and the moſt numerous part of the community, the advantages reſulting from it, have hitherto in great meaſure been loſt, either from the confined circumſtances of the poor, or from their prejudices againſt ſo extraordinary an innovation in practice.

At length, however, examples of the dreadful effects of the Natural, and the wonderful ſucceſs of the Artificial Diſeaſe, have overcome theſe ill-founded prejudices, and nothing ſeemed wanting, to enable the poor to reap the benefit of this practice, but an eſtabliſhment ſuited to their condition and circumſtances.

In London alone upwards of ten thouſand children annually die under ſeven years of age, a great part of whom fall victims to the Natural Small-Pox; but, till very lately, the poor had no means of avoiding this diſeaſe by Inoculation, as no inſtitution for that purpoſe exiſted here till the year 1775, when the Society for General Inoculation of the Poor was firſt eſtabliſhed.

To humane and benevolent minds, it muſt have afforded a high degree of pleaſure, to ſee ſuch ample means extended for ſaving the offspring of the poor; and that their avidity to embrace this ſalutary practice was exceeded only by the ſucceſs of it: for hitherto not a ſingle unfavourable event has taken place; nor has any inſtance occurred to the medical practitioners engaged in this inſtitution, to prove that the infection has been propagated from an inoculated patient.

But though ſucceſs has thus removed the prejudices of the lower claſs of people, and encreaſed their deſire for Inoculation, there are, however, individuals, whoſe oppoſition to ſo benevolent an inſtitution has been proportionally augmented; and much labour has been employed to prove, that whilſt the Inoculation of the rich at their own houſes, is a laudable practice, it is highly injurious to the community, when introduced among the poor. The poor, however, though ſlow in admitting new improvements, are not ſoon to be reaſoned out of ſelf-evident facts; and their willingneſs to try Inoculation, continues to augment with the ſucceſs of the practice.

Poſitions, however, though ever ſo repugnant to experience, when advanced by perſons of acknowledged ability in their profeſſion, will have ſome influence on thoſe individuals, from whoſe approbation and bounty every uſeful inſtitution muſt derive its ſtability. It, therefore, behoves every friend of the poor, to oppoſe facts to bare aſſertions, when the intereſts of ſo uſeful a part of the community are in danger of being eſſentially injured.

Hence it is, that this appeal is made to the Faculty, and other perſons acquainted with the comparative effects of the Natural and Artificial Diſeaſe, in hopes of acquiring ſuch further information, as may more fully aſcertain the ſum of good and evil conſequent on each; and they are reſpectively requeſted to anſwer as many of the following queries as come within the compaſs of their perſonal experience.

I. At what periods of time is the Natural Small-Pox moſt prevalent or fatal?

II. In thoſe places, where the Small-Pox appears at certain intervals, has Inoculation been known to propagate the diſeaſe during ſuch intervals?

III. What diſtempers appear to have been the conſequences of the Natural, and what of the Artificial Small-Pox?

IV. After the Natural Diſeaſe has broke out in any particular diſtrict or quarter of a town, has the practice of Inoculation appeared to ſtop the progreſs of the infection, or has it accelerated it?

V. Has

V. Has Inoculation been practiſed in any particular diſtrict or quarter of a town, without extending the infection to other parts?

VI. At what period of life are people moſt likely to paſs through Inoculation with the leaſt hazard, and at what ſeaſons of the year is the practice moſt ſucceſsful?

VII. After the infection of the Small-Pox has been received, can its operation be deſtroyed by Inoculation?

Communications upon theſe ſubjects, or of facts in general, which tend to throw a light upon the Natural or Artificial Diſeaſe, muſt greatly conduce to improvement in this department of medicine; and as it is propoſed to reduce them into one general hiſtory, now preparing for the preſs, the favours of correſpondents, will then, with their permiſſion, be particularly acknowledged, by J. C. Lettsom

A
COURSE
OF
Mechanical, Magnetical, Optical, Hydroſtatical,
AND
Pneumatical EXPERIMENTS.

To be perform'd by FRANCIS HAUKSBEE; and the Explanatory
Lectures read by WILLIAM WHISTON, M. A.

MECHANICKS.

1ſt DAY. SIR *ISAAC NEWTON*'s Three Laws of Motion, or Nature, demonſtrated by Experiments.

That the Velocity of Falling Bodies is as the Times of Falling, and the Lines of Deſcent in the Duplicate Proportion of thoſe Times.

An Inſtrument to meaſure the Force of Falling Bodies.

Experiments concerning the Sliding, Rolling, and Falling of Bodies.

That Bodies will aſcend as high, as whence they fall by the laſt Velocity impreſs'd, when all Obſtacles are removed.

That Bodies by a compound Force move in a Diagonal Line.

2d.—The Balance and Stilyard, with all their Properties and Uſes ſhewn and explain'd.

The Method of eſtimating the *Momentum*, or Quantity of Motion in any given Body.

The general Principle of Mechanicks eſtabliſhed upon this Method.

Experiments to demonſtrate the different Effects of the ſame Weight or Power acting in different Directions at the ſame Point of any Engine.

The Reſolution of Forces into thoſe of other Directions.

All the various Kinds of Levers explain'd.

3d—All the Phænomena of Pulleys, both ſingle and in all their poſſible Combinations explain'd.

The Power of the Wheel or Axis in Peritrochio explain'd.

The Wedge, with the Method of computing its Force, deduced from Experiments.

The Screw, with the manner of computing its Force.

A Compound Engine.

4th—An Experiment of Lifting a Weight by a Chain of Inflated Bladders, with its Application to Muſcular Motion.

Galilæo's Demonſtration concerning the Strength of the Bones, Timber, *&c.* reduced to Experiment.

The Method of computing the Force of the Air on the Sails of Windmills, and of Ships; and of Water on Water-Wheels, and on the Rudder of a Ship.

Experiments to ſhew the proportional Advantages of large and ſmall Wheels, in all Sorts of Carriages, as Coaches, Waggons, Carts, *&c.*

5th—An Experiment to ſhew, that the lateral Motion compounded with the perpendicular Projection, does not alter the Line of Aſcent or Deſcent in the projected Body.

The moſt conſiderable Objections againſt the Motion of the Earth, anſwered from this Experiment.

That the Line deſcribed by a Projectile is a Parabola.

The Experiments upon which the Art of Gunnery does depend, moſt exactly perform'd.

6th—Experiments concerning Pendulums.

The Deſcription and chief Properties of the Cycloid, and the Application of Cycloidal Cheeks for regulating the Vibrations of Pendulums.

An Experiment to ſhew the Analogy between the Swings of a Pendulum and the Waves of the Sea.

Experiments concerning the Expanſion of Metals by Heat.

7th—The Laws of Motion in the Colliſion of Hard and Elaſtick Bodies.

Experiments concerning the Centrifugal and Centripetal Forces of Solid and Fluid Bodies in Motion.

Experiments in order to eſtimate the Centrifugal Forces of Solid Bodies.

MAGNETICKS.

8th Day. Attractive and Directive Powers of Loadſtones.

The Form or Poſition of Filings of Iron at the Poles and Equator of a Loadſtone.

Magnetick Power acts thro' all Bodies but Iron.

The Attraction of different, and Repulſe of correſponding Poles.

The manner of touching and untouching of Needles.

The Law of Magnetick Attraction diſcover'd.

9th—The Phænomena of *Terrellæ*, or Spherical Loadſtones.

The Direction of Magnetick Needles on the Surfaces of *Terrellæ* nearly towards the Poles.

Their Variation *Eaſt* and *Weſt*.

The Inclinatory or Dipping-Needle, with the Law of the Alteration of that Inclination on the Surface of a *Terrella*.

The Terreſtrial Magnetiſm conſider'd.

The Application of the Dipping-Needle to the Diſcovery of the Longitude and Latitude of Places by Land and Sea.

OPTICKS.

10th Day. Experiments to demonſtrate, that in the Rays of Light the Angle of Incidence is equal to the Angle of Reflection in all Sorts of Surfaces.

The Method of tracing the reflected Rays of Light from Plain, Convex, Concave, and Cylindrical Superficies, with all their wonderful Properties and Uſes, ſhew'd and explain'd.

11th—Sir *Iſ. Newton*'s Reflecting Teleſcope exhibited, and its Conſtruction explained; together with ſome Specimens of its Uſes in obſerving the Planets and Fixed Stars.

12th—Experiments to ſhew the Manner of Refraction.

The Sines of the Angles of Incidence and Refraction, ſhewn to be (at all Degrees of Incidence) in a conſtant Proportion to each other.

An Inſtrument to meaſure the Refraction of Fluids.

The Method of tracing the Refracted Rays of Light thro' Plain, Convex, and Concave Superficies.

13th—An artificial Eye, in which all the Coats and Humours are curiouſly repreſented.

The Diſſection of the Eye.

The Explication of Viſion by the naked Eye, deduced from Experiments.

14th—All the Effects, Properties, and Uſes of Plain, Convex, and Concave Glaſſes, both ſingle and combin'd in Teleſcopes and Microſcopes, ſhew'd and explain'd.

Several Kinds of Microſcopes and Teleſcopes, with the Manner of applying them to their reſpective Objects; together with a Specimen of the Uſes of ſuch Microſcopes and Teleſcopes.

A Multiplying Glaſs.

The Magick Lanthorn.

15th—A particular *Apparatus* to manifeſt and meaſure the Refraction of Air.

The *Camera Obſcura*.

The Theory of Light and Colours, as delivered by Sir *Iſaac Newton*, demonſtrated by ſeveral of his principal Experiments.

The Archbiſhop of *Spalato*'s Experiment, which diſcovered the Cauſe of the Rainbow.

Monſieur *Hugen*'s Experiments, which diſcover the Cauſes of Halo's, of the Mock Suns and Moons, and of inverted Rainbows.

Experiments concerning the blending and Production of Colours by Motion.

HYDROSTATICKS.

16th Day. That Fluids gravitate *in proprio loco*, the upper Parts continually preſſing upon the lower: That this Preſſure is not only propagated Downwards, but even Upwards, and Sideways, according to all poſſible Directions; That a lighter Fluid may gravitate upon a heavier, and an heavier upon a lighter; That a Fluid may ſuſtain a Body heavier *in Specie* than it ſelf, and even raiſe it up; That a Fluid may detain a Body lighter *in Specie* than it ſelf, and even depreſs it. A general Experiment to prove, that a competent Preſſure of a Fluid may produce the remarkable Phænomena of the Torricellian Tube, the Pump, Syringe, Syphon, poliſhed Plates, and other Effects of the like Nature.

17th—That Fluids preſs according to their perpendicular Altitudes, whatever be their Quantities, or however the containing Veſſels be figured. The exact Eſtimate of all manner of Preſſures. That the Velocity and Quantity of Fluids running out at a given Hole, is in the ſubduplicate Proportion of their perpendicular Altitudes. Several Sorts of Pumps. Of the ſinking and floating of Bodies immers'd in Fluids; their relative Gravities and Levities; their Situations and Poſitions. The Phænomena of Glaſs Bubbles and Images accounted for.

18th—An Inſtrument to find out the Specifick Gravity of all Liquors. The Hydroſtatical Balance explain'd, with the Methods of determining the Specifick Gravities of all Sorts of Bodies, whether Solid or Fluid, thereby. The Praxis of the Hydroſtatical Balance, whereby the Specifick Gravities of ſeveral particular Bodies are actually found out. Some Account of the various Uſes of ſuch Enquiries.

PNEUMATICKS *illuſtrated by Experiments for the moſt part Tubular, being ſuch as were wont to be made before the Air-Pump was invented.*

19th DAY. THE ſeveral Phænomena of the Torricellian Experiment exhibited and explained. Other Experiments of the like Nature, with Fluids variouſly combin'd. Several Sorts of Barometers, Thermometers, and Hygroſcopes. The Preſſure of the Air ſhewn by Experiment to be different at different Altitudes from the Surface of the Earth.

20th—The Denſity and Spring of the Air proved by ſeveral ways to be as the Force which compreſſes it, and reciprocally as the Spaces into which it is compreſs'd. From hence an Enquiry is made into the Limits and State of the Atmoſphere.

21ſt—The Effects of the Weight and Spring of the Air in Syringes, Pumps, Siphons, poliſhed Plates, Cupping Glaſſes, Suction: Reſpiration explained by artificial Lungs; That the Air may be ſo diſorder'd by a violent Impulſe, as to require Time to recover its Strength and Elaſticity again.

The more known Properties of the Air eſtabliſhed by the Air-Pump, and other Engines.

22d DAY. THE Air-Pump; the Inſtruments for Condenſing and Transferring of Air; their Fabrick, Operation, and Gages explained.

23d—A Parcel of Air weighed in the Balance; its Specifick Gravity to that of Water determined thereby; an artificial Storm, ſhewing that high Winds may make the Barometer ſink much and ſuddenly.

24th—The Weight, Preſſure, and Spring of the Air prov'd ſeveral ways; by the Senſe of Feeling; by breaking Glaſs Vials; by the Phænomena of Bladders, Glaſs-bubbles, Fountains; the Gardiner's Watering-Pot; the Diving-Bell, *&c.*

25th—The Torricellian Tube *in Vacuo*; Quickſilver raiſed to the uſual Height of the Weather-Glaſs, by the bare Spring of a little included Air; *Otto Gerick*'s Hemiſpheres; and that denſe Air has the ſame Advantage over common Air, as that has over a *Vacuum.*

The Ebullition of Liquors in *Vacuo*; the Quantity of Air contain'd in them; the Suſtentation of Fumes and Vapours; the Deſcent of Bodies *in Vacuo.*

The more hidden Properties of the Air conſider'd by the help of the like Engines.

26th DAY. THE Influence of the Air examin'd as to the Cauſes of Magnetiſm; the Elaſticity of Springs; the Cohæſion of the Parts of Matter; the Sphericity of the Drops of Fluids; the Aſcent of Liquors in capillary Tubes, and between Glaſs-Planes in the Curve of the Hyperbola, both by the Attractive and Repulſive Power of the Glaſs.

27th—The Influence of the Air, as to Sounds, Fire, and Flame; the Conſumption of Fuel; the firing of Gunpowder; the Effects of rarified, condenſed, and burnt Air upon the Life of Animals.

28th—A Piece of Phoſphorus *in Vacuo*; new Experiments concerning the Mercurial Phoſphori; Experiments concerning the Electricity of Bodies.

Every SUBSCRIBER *is to pay Three Guineas; One Guinea at the Time of Subſcription, and the Remainder, the Firſt Day of the* Courſe.

SUBSCRIPTIONS *are taken in at Mr.* Whiſton'*s, in* Great Ruſſel-Street; *and at Mr.* Hauksbee'*s, in* Crane-Court *in* Fleetſtreet; *where the Courſe is to be perform'd.*

Advertiſement.

AIR-Pumps, or Engines for Exhauſting the Air from proper Veſſels, with all their Appurtenances; whereby the various Properties and Uſes of that Fluid are diſcover'd and demonſtrated by undeniable Experiments. Engines for the Compreſſion of the Air: Fountains, in which the Water, or other Liquor, is made to aſcend by the Force of the Air's Spring. Syringes and Blow-Pipes, with Valves for Anatomical Injections. Hydroſtatical Balances, for determining the Specifick Gravity of Fluids and Solids. The Engine and Glaſſes for the New Way of Cupping without Fire. Scarificators, which at once make either 10, 13, or 16 Inciſions. Weather-Glaſſes of all Sorts, as Barometers, Thermometers, *&c.* Reflecting Teleſcopes, by which in ſo ſhort a Length as Six Feet, all that has hitherto been diſcovered in the Heavens (by the longeſt Teleſcopes of the common Conſtruction) may be obſerved.

ALL the above-mention'd Inſtruments, according to their Lateſt and Beſt Improvements, are made and ſold by FRANCIS HAUKSBEE, in *Crane-Court* in *Fleetſtreet*, *London*.

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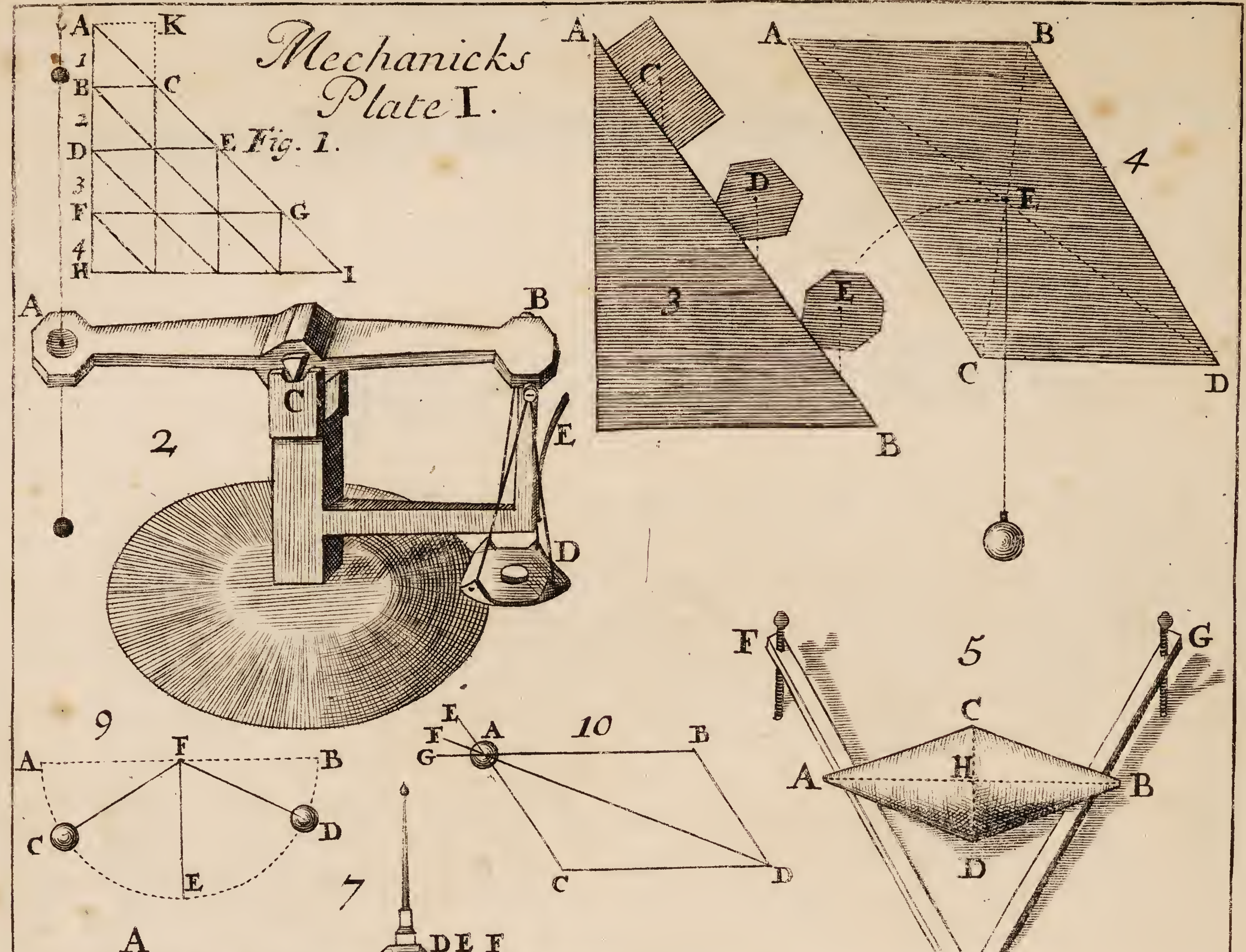
Mechanicks Plate I.



Sutton Nicholls sculp.

MECHANICKS.

An Explication of the Firſt PLATE.

FIGURE. 1. This belongs to *Galilæo*'s famous Demonſtration of the Velocities and Times of Bodies deſcending by an uniform Force, ſuch is that of Gravity here below: And ſhews that they will ever fall in equal Times, 1, 2, 3, 4, *&c.* according to the odd Numbers, 1, 3, 5, 7, *&c.* or the Trapezia B C D E, D E F G, F G H I, *&c.* and by conſequence, that their Velocity will increaſe uniformly in Proportion to the Lines B C, D E, F G, H I, *&c.* or to the Times of Deſcent. And that the entire Lines of their Deſcent will be as the Triangles A B C, A D E, A F G, A H I, *&c.* or as the Squares of thoſe Times, 1, 4, 9, 16, *&c.*

Fig. 2. This is a ſtrong Balance for an Experiment to prove the former Propoſition; by ſhewing that any Bullet or Ball, when it falls from four Times the Height, has twice, from nine Times the Height has thrice its former Velocity or Force; and will accordingly raiſe a double or triple Weight in the oppoſite Scale, to the ſame Height, and no more; and ſo for ever.

Fig. 3. This ſhews how Bodies upon an inclin'd Plane will *ſlide*, if the Perpendicular through the Center of their Gravity falls *within*; and will *rowl*, if that Perpendicular fall *without* their common Section.

Fig. 4. This ſhews that an oblique Body will ſtand, if the Perpendicular through its Center of Gravity cut the Baſe; and that it will fall, if it cut not the Baſe: As accordingly we ſtand when the Perpendicular through the Center of Gravity of our Bodies falls within the Baſe of our Feet; and we are ready to tumble when it falls without the ſame.

Fig. 5. This is a Conick Rhombus, or two right Cones, with a common Baſe, rowling upwards to Appearance, or from E towards F and G: Which Points are ſet higher by Screws than the Point E. But ſo that the Declivity from C towards A and B is greater than the Aclivity from E towards F and G. Whence it is plain, that the Axis and Center of Gravity do really deſcend all the Way.

Fig. 6. Is a Balance, in an horizontal Poſture, with weights at Diſtances from the Center reciprocally proportional to themſelves; and thereby *in Æquilibrio.*

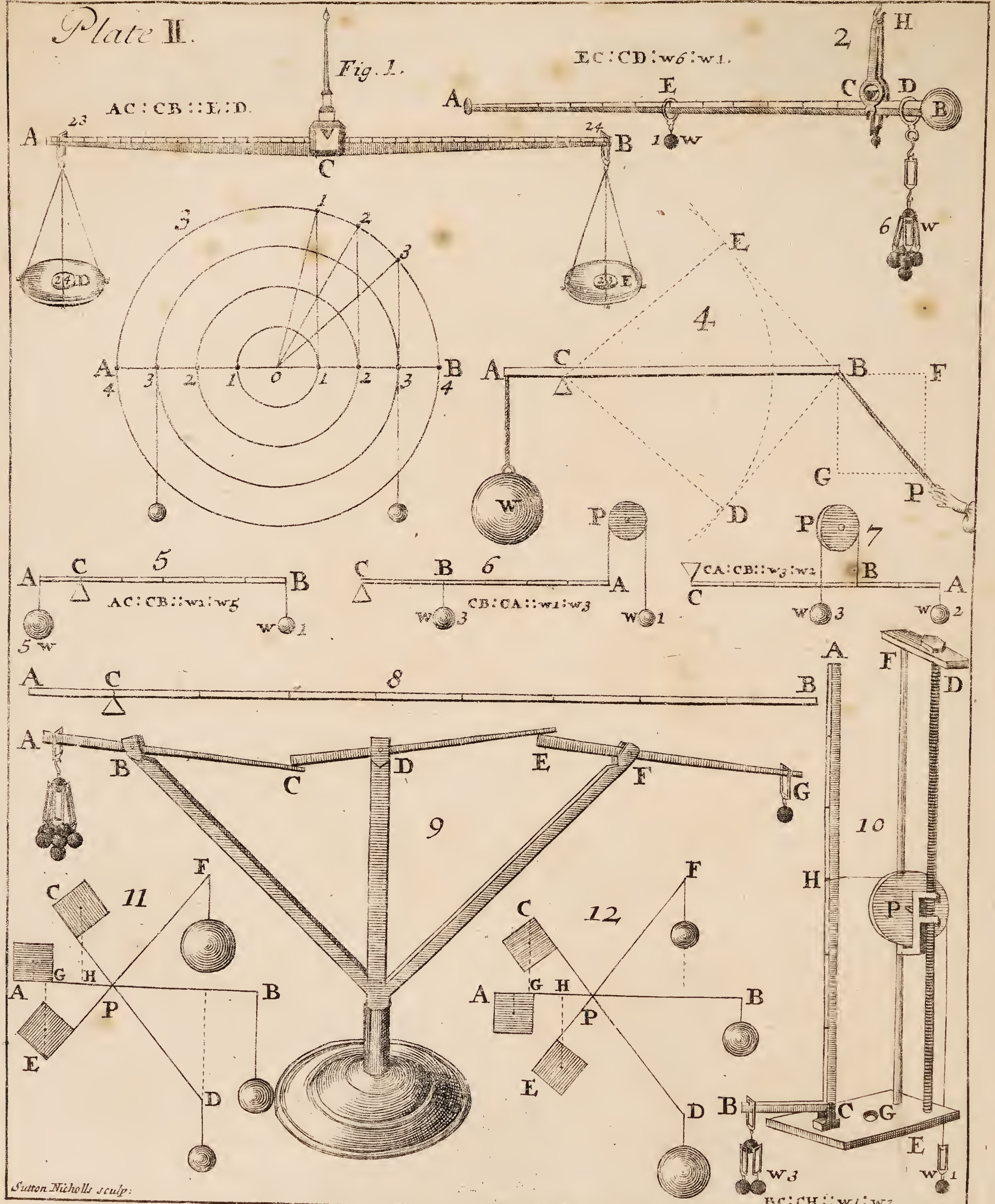
Fig. 7. and 8. Are two other Balances in an horizontal Poſture, with ſeveral Weights on each Side, ſo adjuſted, that the Sum of the Motion on one Side, made by multiplying each Weight by its Velocity, or Diſtance from the Center, and ſo added together, is equal to that on the other: And ſo all is ſtill *in Æquilibrio.*

Fig. 9. Belongs to the Laws of Motion, in the Colliſion of Bodies to be tried with Pendulums, or otherwiſe, both as to Elaſtical Bodies, and to thoſe which are not Elaſtical.

Fig. 10. Belongs to that Famous and Fundamental Law of Motion, that if a Body be impell'd by two diſtinct Forces in any Proportion, it will in the ſame Time move along the Diagonal of that Parallelogram, whoſe Sides would have been deſcrib'd by thoſe diſtinct Forces; and that accordingly all Lines, in which Bodies move, may be conſider'd as Diagonals of Parallelograms; and ſo may be reſolved into thoſe two Forces, which would have been neceſſary for the diſtinct Motions along their two Sides reſpectively: Which grand Law includes the Compoſition and Reſolution of all Motions whatſoever, and is of the greateſt Uſe in Mechanical and Natural Philoſophy.

Fig. 11. Are two polite Plains inclined to one another, to ſhew that the Deſcent down one Plain will elevate a Ball almoſt to an equal Height on the other.

Plate II.



Sutton Nicholls sculp:

An Explication of the Second PLATE.

FIGURE. 1. Is the deceitful Balance; which yet is *in Equilibrio*; becauſe the Weights 23 and 24 are reciprocally proportional to their Diſtances from the Center of Motion. Now this Cheat is eaſily diſcover'd by changing the Poſition of the Weights, and putting each of them into the other Scale, which will then be very unequal, or nearly as 11 to 12.

Fig. 2. Is that ſort of Balance which is called a Stiliard, and of frequent Uſe among us. It is only a Common Balance, with Weights at Diſtances from the Center of Motion reciprocally Proportionable to themſelves: Only here the Length of Part of the Beam is compenſated by a large Ball or Weight B, fixed to the ſhorter Beam; and one Weight as w removed along equal Diviſions is made uſe of to weigh ſeveral others, as 6 w. *&c.*

Fig. 3. Is deſign'd to ſhew how any Force is diminiſh'd by its Obliquity; and that a Weight hung obliquely at 3, 2, 1, in the Circumference of a Circle or Wheel, is of no more Efficacy, as to the turning of the Wheel round, than if it were hung perpendiculary at the correſponding Points 3, 2, 1, in the Semidiameter of the ſame Circle.

Fig. 4. Is the Demonſtration of the former Caſe, by ſhewing that in thoſe Circumſtances the Force P B is reſolved into two B F and B G, of which B F pulls directly from the Center, and is of no Uſe to the turning the Wheel round: And ſo all the remaining Force is repreſented by the perpendicular Force B G, which is wholly ſpent in turning it round. So that as B P is to B G, ſo is the whole oblique Force, to the real or direct Force: Or ſo, in the ſimilar Triangle B E C, is B C the whole oblique Radius, to C E the Perpendicular: Or ſo in the foregoing Figure is O 1, O 2, O 3, the common Hypotenuſe or entire Radius, to O 1, O 2, O 3, the Baſes or ſhorter Radij, where the String cuts the entire Radius perpendicularly.

Fig. 5. Is the firſt Sort of Lever, where C the Prop is between the Reſiſtance to be overcome, or Weight to be moved 5 w, and w 1 the Power or Weight to move the other by: And is ſo like the Caſe of the Balance or Stiliard, that it needs no particular Explication. A Crow of Iron is of this Sort.

Fig. 6. Is the ſecond Sort of Lever, where the Reſiſtance to be overcome, or Weight to be moved w 3, is between the Prop C and the Point A, to which by the means of the Pulley P, the Power or Weight to move the other by, is applied. Bakers Knives for cutting Bread are commonly of this Sort.

Fig. 7. Is the third Sort of Lever, where the Reſiſtance to be overcome, or Weight to be moved, w 2 is at one End, the Prop at the other, and the Power or Weight w 3 between them. A Ladder lifted up by the Middle, in order to be rear'd, where one End is fixed, is of this Sort. Only the Force being in this Caſe nearer the Prop than the Reſiſtance to be overcome, or Weight to be moved, this Sort of Lever diminiſhes Force inſtead of increaſing it, and is therefore of little Uſe.

Fig. 8. Is a common Lever of the firſt Sort, with its Prop and equal Diviſions, fit to be uſed as the Stiliard.

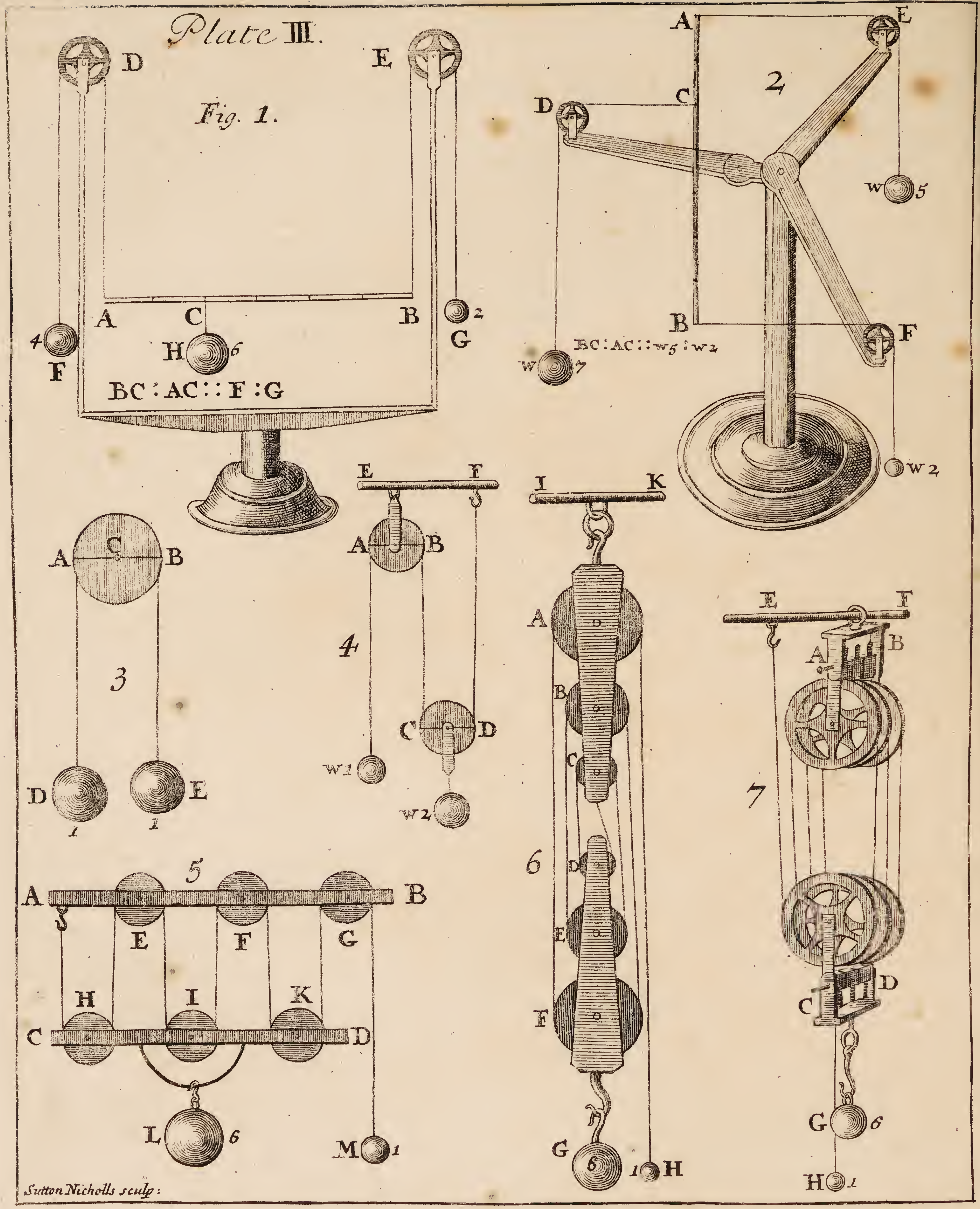
Fig. 9. Is a compound Lever of the firſt Sort, as long as the ſingle one juſt above it, where a Weight at G, by being doubled three ſeveral Times, will raiſe eight Times its own Weight at A, as well as the other does it at once. This laſt is therefore of the ſame Force as the former, and no more; and by being compounded, is leſs conſiderable than the other.

N. *B.* Had the Proportion in the Compound Lever, *Fig.* 9. been otherwiſe, as ſuppoſe the Part B C on one Side of the Prop B three Times the Length of A B on the other Side, and the ſame in the other two Levers C E and E G; then the Weight G being but the 27th Part of the Weight at A, will be *in Æquilibrio* with it.

Fig. 10. Is a bended Lever of the firſt Sort, where C the Prop is at an Angle, and the Force is increas'd with C H, the Diſtance of the Weight w 1, which by the means of the Pulley P, is applied to the longer Part of the Lever; and in this Leaver, the Power is to the Reſiſtance reciprocally as their Diſtances. An Hammer drawing out a Nail is ſuch a bended Lever.

Fig. 11, 12. Shew that Levers or Balances that are even when horizontal, may be uneven in other Poſitions; that is, too light when the Center of Gravity of one Weight is fix'd to the Lever or Balance above, and it is elevated; or below, and depreſs'd: Becauſe the Perpendicular cuts the horizontal Line too near the Center in theſe Caſes.

Plate III.



Sutton Nicholls sculp:

An Explication of the Third PLATE.

FIGURE 1. Is a Sort of Compound Lever of the ſecond Kind, where the Weight H 6 is unequally born by the Weights F 4 and G 2, which are reciprocally proportional to the Diſtances C B and C A; and are accordingly *in Æquilibrio.* Whence we ſee how two Men may bear unequal Parts of the ſame Weight, in Proportion to their Nearneſs thereto.

Fig. 2. Is another Engine of the ſame Nature with the former; where the Lines D C, A E, B F, and the Lever A B, are parallel to the Horizon; but the Lines on which the Weights hang D w 7, E w 5, F w 2, are perpendicular thereto; and here a Force or Weight pulling at the Point C ſuſtains the unequal Weights w 5 and w 2 *in Æquilibrio*: Provided the Diſtances C B and C A be reciprocally proportional to thoſe Weights. Whence we learn, how Horſes of unequal Strength may be duly fitted to preſerve equally in their Labour; *viz.* by taking care that the Beam by which they both draw a Weight or Waggon, may be divided at the Point of Traction as C, in reciprocal Proportion to ſuch their Strength.

Fig. 3. A B is an upper Pulley, of no direct Advantage, but for Readineſs of the Motion, as increaſing not the Power at all; equal Weights being ever required to raiſe others.

Fig. 4. Is an upper and an under Pulley connected together; where the upper being of no Efficacy, the lower does however double the Force, as is ever the Caſe in ſuch Pulleys.

Fig. 5. Is a Compound Pulley of three upper and three under Pulleys, all communicating together; where therefore the whole Weight is divided among 6 Strings; and ſo 1 Pound balances 6 Pound. The laſt String B M 1, as paſſing beyond the laſt upper Pulley, not being here to be reckon'd of any Conſequence.

Fig. 6. and 7. Theſe are Boxes of the ſame Number of upper and under Pulleys with the former; only in other Poſitions, and depend on the ſame Principle entirely.

* * *

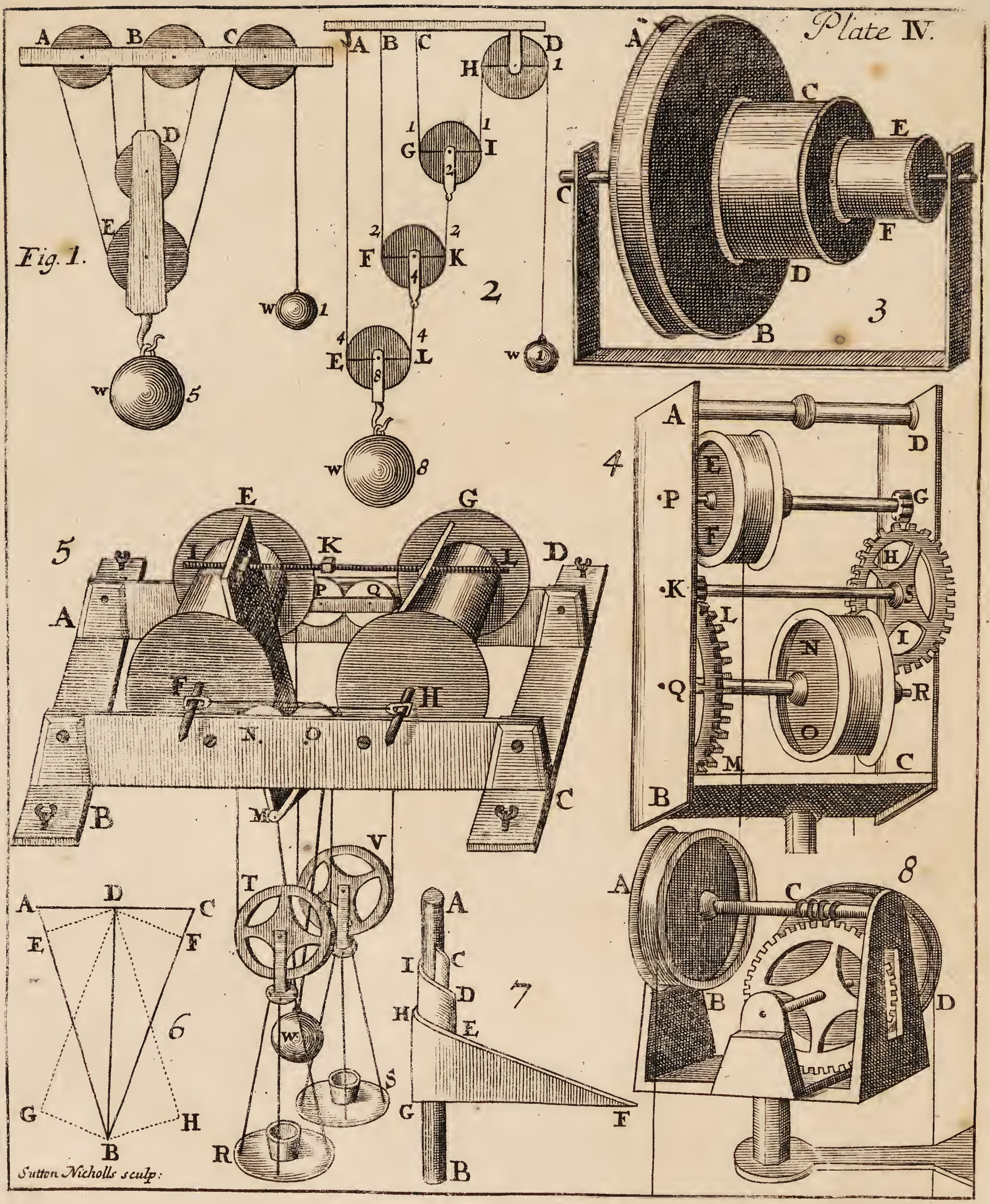


Plate IV.

Sutton Nicholls sculp:

An Explication of the Fourth PLATE.

FIGURE 1. Is a Syſtem of Pulleys connected together, whereby the Force is increaſed by Addition in Proportion to the Number of Cords; ſo that one Pound, w 1, ſuſtains five Pounds, w 5, as muſt happen from the Equality of the ſtretching of the whole Cord, and the conſequent Diviſion of the whole Weight into five equal Parts, as equally ſupported by them all.

Fig. 2. Is a Syſtem of Pulleys not connected together, whereby the Force is increas'd, for every lower Pulley; according to the Numbers, 2, 4, 8, in a double Proportion; becauſe every lower Pulley doubles the Force of the former; as is evident at the firſt Sight; ſince the Velocity of Aſcent or Deſcent of the greater Weight is every Time but half ſo great as before.

Fig. 3. Is the Axis in Peritrochio; or Wheel, with its Axel; where any Weight or Force applied round E F, or C D, or A B, has juſt ſo much greater Power to move the Wheel, or entire Machine about the Axis, as the Velocity or Diſtance from the Geometrical Axis it ſelf is greater. Nor is there any farther Difficulty in this plain Engine.

Fig. 4. This is only a Train of Wheel-work; which by Compoſition of Wheels vaſtly increaſes the Force. Thus ſuppoſe the Diameter of the Barrel E F, be ten times the Diameter of the Pinion G: And the Diameter, or Number of equal Teeth in G, be one tenth of the Diameter, or Number of equal Teeth in H I: And the Diameter and Velocity of the Teeth in H I, be ten times the Diameter and Velocity of the Pinion K; and the Diameter or Number of equal Teeth in K, be one tenth of the Diameter, or Number of equal Teeth in L M; And that the Barrel N O, be of the ſame Diameter with the Wheel LM. Then a Weight on the Barrel EF, will balance a Weight one hundred times as heavy upon the Barrel N O; which is done by its moving an hundred Times as ſwift as the other. For the Velocity in the firſt Barrel E F, to that of its Pinion G, is as ten to one; and that in the Wheel H I, to that in its Pinion K, is alſo as ten to one. While the Velocities at each Wheel, and its correſponding Pinion in the other Wheel, as well as at the Wheel L M, and its Barrel N O, are equal.

Fig. 5. Is a compound Engine, to prove that in a Wedge, as E M G, depreſs'd by a Weight w, or by its own Weight, or by a Stroke, the Force is diminiſhed in Proportion to the Sine of its Aperture, compar'd with the Line of its Depth: So that when the former Sine is double or triple, *&c.* the Force is diminiſhed one half, or one third, *&c.* This is here prov'd by the Wedges ſeparating two Cylinders, which are drawn together by other Weights, in the Scales R and S beneath, when its Sides are ſcrew'd nearer or farther off, to adjuſt their Diſtance to thoſe Weights perpetually.

Fig. 6. Is a Wedge by it ſelf, where the Force is increas'd in the Proportion of the Sines of the Angles of Aperture, D F and D E, to the Radius D B; or is reſolv'd into two Forces, the one perpendicular, and the other parallel to the Plain of the Tree or Timber it is to reeve: And this becauſe the Velocity downward is ever to the Velocity ſide-ways in the Proportion of D B to D F and D E, or to 2 D F. *i. e.* by the Similitude of Triangles, as A B or C B to A C.

Fig. 7. Is a Paper Wedge, H F G coil'd round a Cylinder, and ſo repreſenting a Screw; and ſhews that its Force muſt be increas'd in Proportion to the Progreſs along its Cylinder, when it is compar'd with the Circumferences on the ſame Cylindrical Surface, or as H F to H G.

Fig. 8. Is a compound Engine to explain and meaſure the Power of the Screw: from whence it appears, that the Force of Screws is reciprocally proportional to the Diſtance of the *Helix*'s or Threads which compoſe them.

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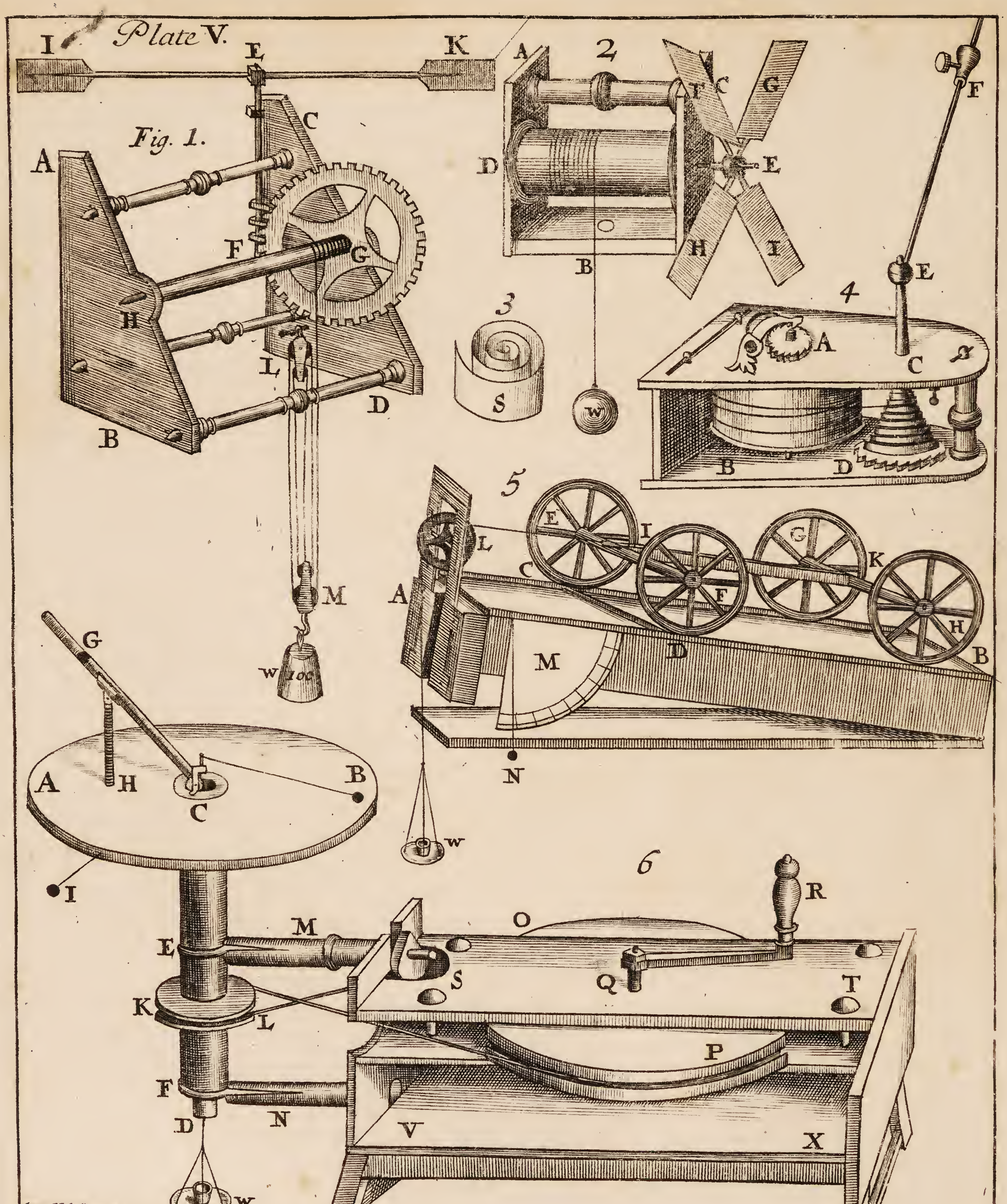
Plate V.



Sutton Nicholls del. & sculp.

An Explication of the Fifth PLATE.

FIGURE I. Is a Compound Engine in which all the ſeveral Mechanical Powers are combin'd: as the Wheel and Axle G H: The Balance or Lever I K: the Screw F; which includes the Wedge: and the Pulley L M. The entire Force of this Engine is to be computed by compounding the ſeparate Forces together.

Fig. 2. Is a Windmill; whoſe Force is here repreſented, by its raiſing a Weight on a Barrel. The Wind is ſuppoſed to blow parallel to the Axis, from E towards D; its ſeveral Sails have their Plains nearly 45 Degrees oblique to the Plain through the middle of thoſe Sails: Two of them inclining, and two reclining. By this Means the Wind falling at about 45 Degrees obliquity on the Plain of each Sail; the Breadth of each Sail is a Diagonal of a Square, one of whoſe Sides is parallel to the Direction of the circular Motion, and has its full Force; and the other is perpendicular thereto, and ſo has no Effect as to that circular Motion at all. And as much as the Side of a Square is leſſer than the Diagonal, ſo much of the whole Quantity of the Wind is loſt on every ſingle Sail. But then each Pair along the ſame Line, by the different Situation of thoſe Sails, agreeing in the ſame Motion, the whole united Quantity is more than the ſingle Quantity upon one equal Sail directly expos'd to the ſame Wind, as much as two Sides of a Square are greater than the Diagonal. But this without the Conſideration of the weakning of the Force of the Wind by the Obliquity of Incidence; which alters the former Proportion: for this alſo diminiſhing the Force in the ſame Proportion with the former Diminution of the Quantity of the Wind, the whole Diminution will ever be as the Squares of that Quantity; or as the Squares of the Sines of the Angles of Incidence: wherefore in this Caſe of Four oblique Sails of 45 Degrees will be equivalent to Two direct ones.

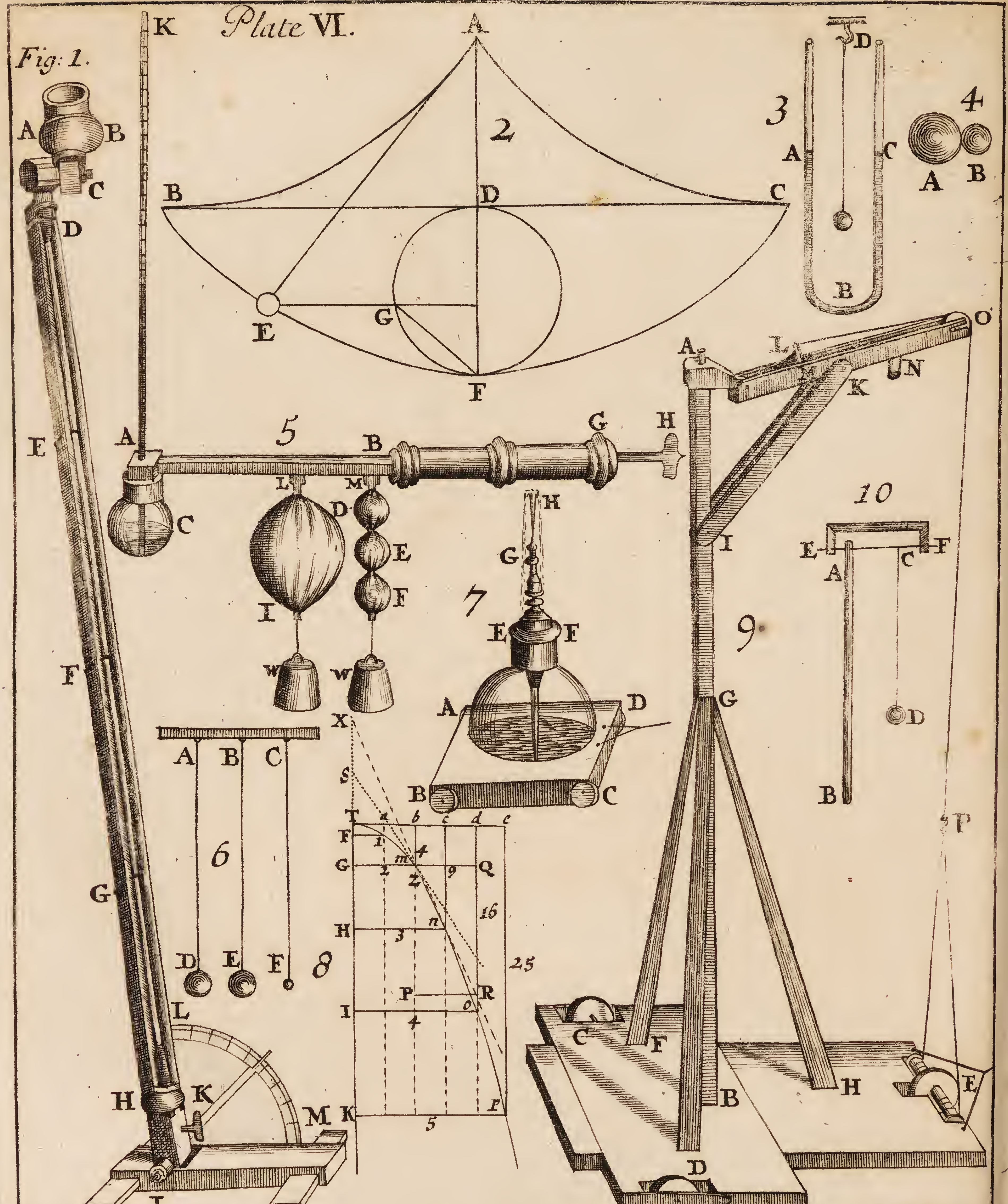
Fig. 3. Is the elaſtical ſpiral Spring of a Watch, out of its Box, and unwinding it ſelf more weakly, us it is leſs reſtrained.

Fig. 4. Is the ſame Spring in its Barrel A B join'd by a Chain to its Fuſee C D, or ſpiral Line about a Cone, which Cone has the Semidiameter or Diſtance from its Axis in the very ſame Proportion, greater as the Spring is weaker, and leſſer as the Spring is ſtronger: that ſo the abſolute Force on the Wheels of the Watch may be ever the ſame, for the exact Equality of their Motion in all Caſes.

Fig. 5. Is an Imitation of a Waggon or Coach, with its fore Wheels E F, either equal (as here,) or elſe leſſer, or greater, than the hinder G H; to be drawn by a Weight w in the Scale, either upon an Horizontal, or upon an Inclined Plain A B, and to get over any Obſtacle as C D: The Quadrant M, and Bullet N, are to ſhew the Quantity of the Elevation of that Plain, for the Tryal of Experiments relating to all ſuch Sort of Vehicles.

Fig. 6. Is a ſtrong Machine, with a Wheel O P, and its Winch R, and String O P L K, its leſſer Barrel K L, circular Table A B, Scale with a Weight w, ſuſpended by a String that comes through the hollow Axis C D, and oblique Tube G C, in which Mercury or a Bullet is included; its Screw H; its Balls I and B, and their Strings; To ſhew that Motion once begun always continnes, till ſome other Cauſe ſtops it: That abſolute and reſpective Motion are entirely different: And to ſhew withal the Endeavour of Bodies that move circularly to recede from the Center of their Motion, on inclined, as well as horizontal Plains, and that in the ſame Circle in a duplicate Proportion to their Velocity.

Plate VI.



Sutton Nicholls sculp:

An Explication of the Sixth PLATE.

FIGURE 1. Is an Inſtrument to ſhew the various Parabola's that are made by Projectils, and particularly the Truth of the ſeveral Rules in the Art of Gunnery. Wherein A B is a Tunnel full of Quickſilver, D K is a Glaſs Tube, let into a Groove or Frame of Wood for its Support, and at K is a fine Stem, accommodated to the Arch of a Quadrant L M, and turning upon its Center, to direct the projected Quickſilver to any Angle; while the Tube's perpendicular Altitude, or the Force that produces the Projection, is either the ſame, or altered by a different Inclination at Pleaſure, according to the Nature of the ſeveral Experiments.

Fig. 2. Is a Cycloid with its equal Sides AB, AC, and pendulous Body E, oſcillating therein. And, *Note*, That by the Make of the Figure, the Line B C is equal to the Circumference of the Circle D G F, by which it was deſcrib'd; that the Length of the Cycloid it ſelf is four times that Circle's Diameter; that every Part of it from F the *Vertex* is ſtill double to the Chord of the Correſpondent circular Arch G F; that its included Area B D C F, is Three times the Area of the former Circle; that the Force upon the Pendulum at any Point E, is exactly proportional to the Diſtance along the Cycloid of the Point from the *Vertex*, as E F; and that therefore the Time of every Oſcillation, in all Angles whatſoever, is always equal.

Fig. 3. ACB is a Syphon with Quickſilver from A to C, and a Pendulum of half that Length; to ſhew here alſo that the Force is as the Line to be deſcrib'd, and that by Conſequence the Vibrations in the Syphon are all equal: as alſo to ſhew that they are equal to thoſe of a Pendulum, of half the ſame Length: As is plain from the former Caſe of the Cycloid, where the Length of the Pendulum is half that of the Cycloid in which the Body moves.

Fig. 4. A B are two Spheres, to denote the ſeveral Laws of Motion in the Colliſion of Bodies, whether Elaſtical or not Elaſtical, to be tried in the Cycloid, or in a Circle, with proper Corrections: Which Experiments yet are moſt of them too difficult for ſuch a Courſe as this is.

Fig. 5. Is an Inſtrument to explain muſcular Motion; ſuppoſing the Muſcles to be ſome way like a String of Bladders; by ſhewing that a ſmaller Quantity of an elaſtical Fluid may equally raiſe equal Weights with a larger; and to ſhew exactly what Quantity is neceſſary for any particular Effect. For thus will the leſſer Quantity of Air, (meaſured in both Caſes by the Gage C A K, as condens'd by the Syringe H A) equally raiſe an equal Weight to the ſame Height by the leſſer three Bladders, that the greater Quantity raiſes the ſame by the one larger Bladder.

Fig. 6. Are ſeveral Pendulums of ſeveral Sorts of Matter, heavy and light; where the Centers of Suſpenſion and Oſcillation are equally diſtant, and the Times of thoſe Oſcillations are all equal. This alſo hints the other remarkable Phænomena of Pendulums; *viz.* that the Semicircular and Cycloidal Times of Oſcillation are to each other as 34 to 29: That in both the Length of the Strings of Pendulums are in a duplicate Proportion to their Times of Oſcillation; and that the Heights of Roofs, *&c.* may be found from the Times of the Oſcillations of Pendulous Bodies fixed to them, on the known Hypotheſis that a Pendulum of 39⌊2 Inches vibrates in one Second of Time.

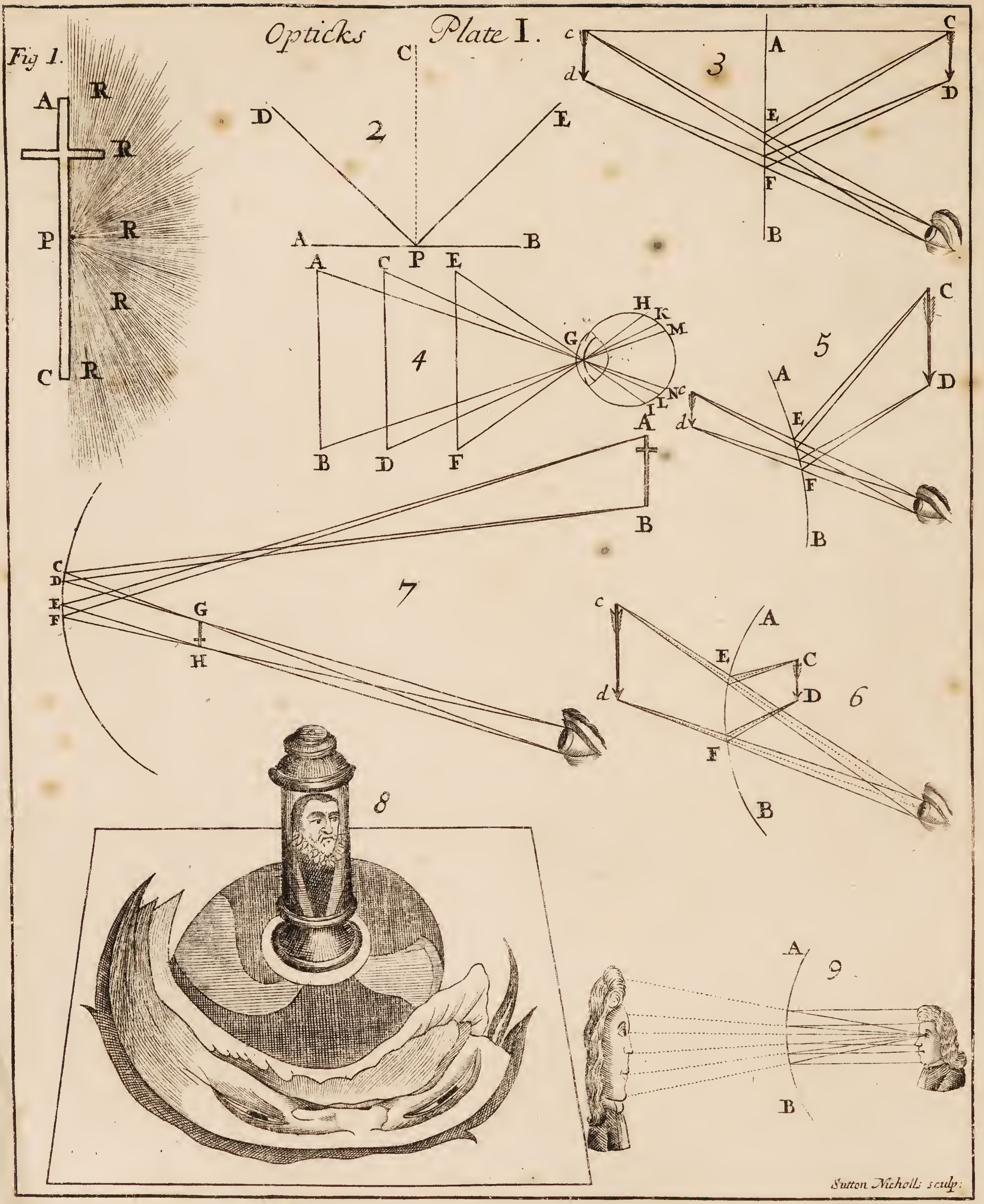
Fig. 7. Is a Fountain running on Wheels, and made by Air condens'd on the Surface of Quickſilver, and ſo forcing the Quickſilver to aſcend through the Pipe G: And is to ſhew that the Lines of Projectils, or other Bodies, are not alter'd by the common Motion of the whole Inſtrument or Floor on which they are plac'd; and that all Motions on the Earth, if it move, will be the ſame as if it ſtand ſtill.

Fig. 8. Is a Parabola with the ſeveral Lines belonging to it, in order to demonſtrate the Doctrine of Projectils; and particularly the Art of Gunnery.

Fig. 9. Is an Engine moving on Wheels, that lets a Ball fall down from a Groove through a Hole, as it is in Motion; to ſhew that it will then fall on the ſame Point of the Frame that it falls upon when it is at reſt; as does a Stone let fall from the Top of the Maſt of a Ship under Sail: and that all reſpective Motions on the Earth muſt be the very ſame, while it ſelf moves as if it were at reſt.

Fig. 10. Is a Cylindrical Iron A B, ſwinging on a Pin E F, in the very ſame time that a pendulous Body D of two thirds of its Length C D does; to ſhew that two thirds is the Center of Oſcillation or Percuſſion in all ſuch priſmatick or cylindrical Bodies.

Opticks Plate I.



Sutton Nicholls sculp:

OPTICKS.

An Explication of the Firſt PLATE.

FIGURE 1. Repreſents the Foundation of Viſion, and of all Opticks whatſoever, by exhibiting to the Eye a Specimen how the Rays of Light do as well originally, as after Reflection or Refraction, ſpread themſelves in right Lines from each Point in every viſible Object, as P, to each other Point, as R, R, R, R, R, every way, to be receiv'd by the Eye in any direct Poſition whatſoever.

Fig. 2. Repreſents the known Law of Reflection; that the Angle of Incidence C P D, is equal to that of Reflection C P E, or that the Angle of Inclination D P A is equal to the other E P B.

Fig. 3. Shews the Reaſon why a plain Looking-glaſs, as A E F B, exhibits the Object C D by the Image *c d*, which is equal to C D, and equidiſtant from the Glaſs A *c* = A C: And in an erect Poſture; all depending only on the Equality of the Triangles, whoſe Vertices are C *c*: D *d*, and have their common Baſes below E and above F, which Glaſs by forming the ſame Image *c d*, ſo to the Eye, as if the real Object C D was at *c d*, muſt needs ſhew that Picture in the Place aſſign'd, without any Inequality of Diſtance or Magnitude, or any Inverſion.

Fig. 4. Shews the Reaſon why the ſame or equal Object, as A B, C D, E F, appears larger when it is nearer, and ſmaller when farther off: *viz.* on account of the Inequality of the Angles A G B, or M G N, and C G D, or K G L, and E G F or H G I, and the conſequent Inequality of the Pictures made by the Rays at the Bottom of the Eye.

Fig. 5. Shews the Reaſon why a Convex Looking-Glaſs, as A E F B, exhibits the Object C D by the Image *c d*, both nearer to the Glaſs, and leſſer than it ſelf; but ſtill in an erect Poſture. All depending only on the different Bend of the Circle between E and its lower Point, between F and its upper Point; which cannot make the Angles of Reflection or Inclination equal, as they muſt needs be in all ſuch Reflections, without making the Vertices of the Angles, as *c* and *d*, nearer the Glaſs than C and D: And ſo the apparent Picture or Diameter *c d* leſſer than that of the Object C D, though without any Inverſion.

Fig. 6. Shews the Reaſon why a Concave Glaſs, as A E F B, exhibits an Object plac'd nearer the Glaſs than the Center, as C D by the Image *c d*, remoter from the Glaſs, and larger than it ſelf; *viz.* for Reaſons juſt contrary to thoſe under the fifth Figure foregoing.

Fig. 7. Shews the Reaſon why a Concave Glaſs, as C D E F, exhibits an Object, if it be plac'd remoter than the Center, as A B, inverted, and at different Diſtances between the Eye and the Glaſs; according to the Length or Shortneſs of its own Diſtance, as BC or AD, *viz.* Becauſe the Rays from the ſame Point ſtill croſs one another, as at G and H, before they fall upon the Eye; and ſo by forming an inverted Image make it impoſſible for the Eye to ſee the Object in any other Poſition than that the Image has; which Image indeed it ſelf is the only proper Object of the Eye, in all ſuch Caſes whatſoever.

Fig. 8. Is a Picture in Confuſion; but rectified by a Convex Cylinder, and thereby brought into exact Order again.

Fig. 9. Repreſents an Image in a Cylindrical Concave Surface, when the Eye is in a Plain perpendicular to its Axis; ſo that lengthways it is as a Plain, and breadthways as a Concave *Speculum*: Which therefore makes the Picture longer, but not wider. The contrary will happen in a Convex *Speculum*, which will make it ſhorter but not narrower, for the like Reaſon.

Plate II.

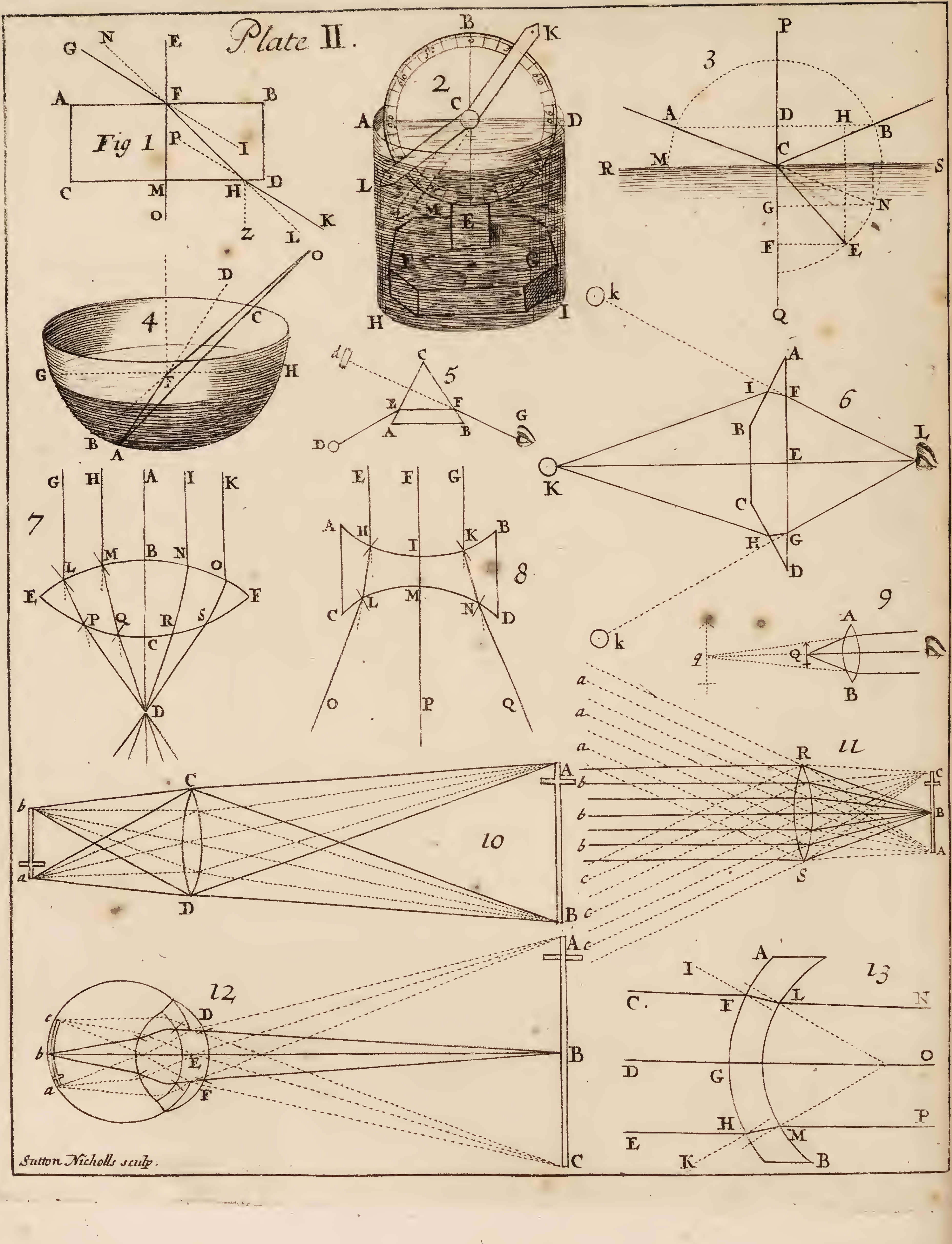


Fig 1
G N E A F B P I C M H D O Z L K
2
B K C A D L M E F G H I
3
P A D H B C R M S G N F E Q
4
O D C G F H B A
5
C d E F A B D G
6
k A I F B E K L C H G D k
7
G H A I K L M B N O E F P Q R S C D
8
E F G A H I K B C L M N D O P Q
9
A q Q B
10
C A b a D B
11
a a a R b b b b c c c S C B A
12
A c c D b E B a F C
13
A I C F L N D G O H P E M K B

Sutton Nicholls sculp.

An Explication of the Second PLATE.

FIGURE 1. Shews that an Object, as K, ſeen through a plain Glaſs, whoſe Sides A B, C D, are parallel, by the Eye at G, appears out of its true Place; and this ſo much the more as the Glaſs is thicker: While at the ſame time the two Surfaces do exactly balance each other's Refraction, and make the two Rays H K, G F exactly parallel.

Fig. 2. Exhibits a plain Method of meaſuring the Refraction of Fluids at all Angles, and of proving thereby that it is always in one fixed Proportion of the Sines, as the next Figure will explain it. For if the moveable Rule K C L, with its meaſuring Circle A B D E fix'd by the Prop E, to a heavy Pedeſtal F G, in a large Glaſs A H I D, be ſo far immers'd in the Fluid, that the Center C may be in the Surface of the Fluid, and one of its Legs C L be ſo far bent from a rectilinear Poſition, that the Refraction of the Fluid can juſt make it appear as if it were in a ſtrait Line, the Angle B C K, or its equal M C E, is the Angle of Incidence: And L C E the Angle of Refraction: And L C M the Difference, or the refracted Angle.

Fig. 3. Is for the Illuſtration of the former Propoſition, and ſhews the Sines afore-mentioned; as A D or G N (for they are ſuppos'd equal, and the Line A C N one ſtrait Line,) is the Sine of the Angle of Incidence, and F E the Sine of the Angle of Refraction, which Sines do in the ſame Fluid at all Angles bear one and the ſame Proportion to each other; till at laſt, if the Refraction be out of a thick Medium into a thin one, and makes the ſecond Sine equal to the Radius, that Ray cannot emerge at all, but will be reflected back by the Surface into the ſame Medium whence it came, along the Line CR.

Fig. 4. Is a Baſon of Water, or other Fluid; to ſhew the common Experiment of Refraction; where a Shilling, or other Object at A, (which is ſo plac'd that it cannot be ſeen by the Eye at O, the Side of the Baſon C interpoſing) is readily ſeen there, as ſoon as the Water or other Fluid is put in to the ſame Baſon, and appears to be remov'd to the Point B.

Fig. 5. Is the Alteration of a round white Object D, as ſeen through a Triangular Glaſs Priſm A B C, by the Eye at G, where the double Refraction of the Glaſs at E and F makes the Object appear at *d*; and that as an oblong colour'd Image; wherein the upper Part is made by the violet Rays, which are moſt refrangible; and the lower by the red Rays, which are leaſt ſo; and the intermediate Parts by thoſe that are refrangible in a mean Degree; after the Order of the Colours of the Rainbow.

Fig. 6. Shews the Nature of a multiplying Glaſs A D, and its Plains A B, B C, C D, *&c.* and the Reaſon why the different Refraction of every oblique Plain, as A B, C D, *&c.* exhibits the ſame Object K as a different Object k, k, *&c.* according to the Number of the oblique Plains: While the direct Plain B C ſhews it ſtill in its own Place: And while the Convolution of the Glaſs on the Axis K L removes all the oblique Images, but does not remove the direct one, on Account of the Change of the Poſition of thoſe oblique Plains, and of the unchanged Poſition of the direct Plain.

Fig. 7. Shews the Effect of the Lens, or double Convex Glaſs, in gathering parallel Rays, as G L, H M, A B, I N, K O, *&c.* towards a Point, as D; becauſe, as in the Caſe of the Priſm above, the Refraction *to* the perpendicular in the Entrance, and *from* it in the Exit of thoſe Rays, do ſtill, by the different Poſition of that Perpendicular, conſpire to unite the ſame Rays.

Fig. 8. Shows the contrary Effect of the double Concave Glaſs, in ſcattering the parallel Rays; and that exactly on the like Account; and ſo this needs no new Explication.

Fig. 9. Shews the Reaſon why a Lens, or double Convex, ſhews a near Object at Q, as more remote at *q*, becauſe it refracts it ſo that the Rays from the ſame Point meet more backward than before: And why it ſhews the ſame Object larger alſo: Which muſt needs be, becauſe every Point in the Object appearing ſo much more backward, and yet in the ſame apparent Angle, its Length and Breadth muſt every where be proportionably enlarg'd.

Fig. 10. Shews how ſuch a Lens inverts Objects, as A, B, *b a*, which it does on Account of the Interſection of the Rays from each Point, in or near the Lens it ſelf: Which neceſſarily infers ſuch an Alteration: juſt as the Images of all Objects are in the Eye in an inverted Poſition, on the like Account.

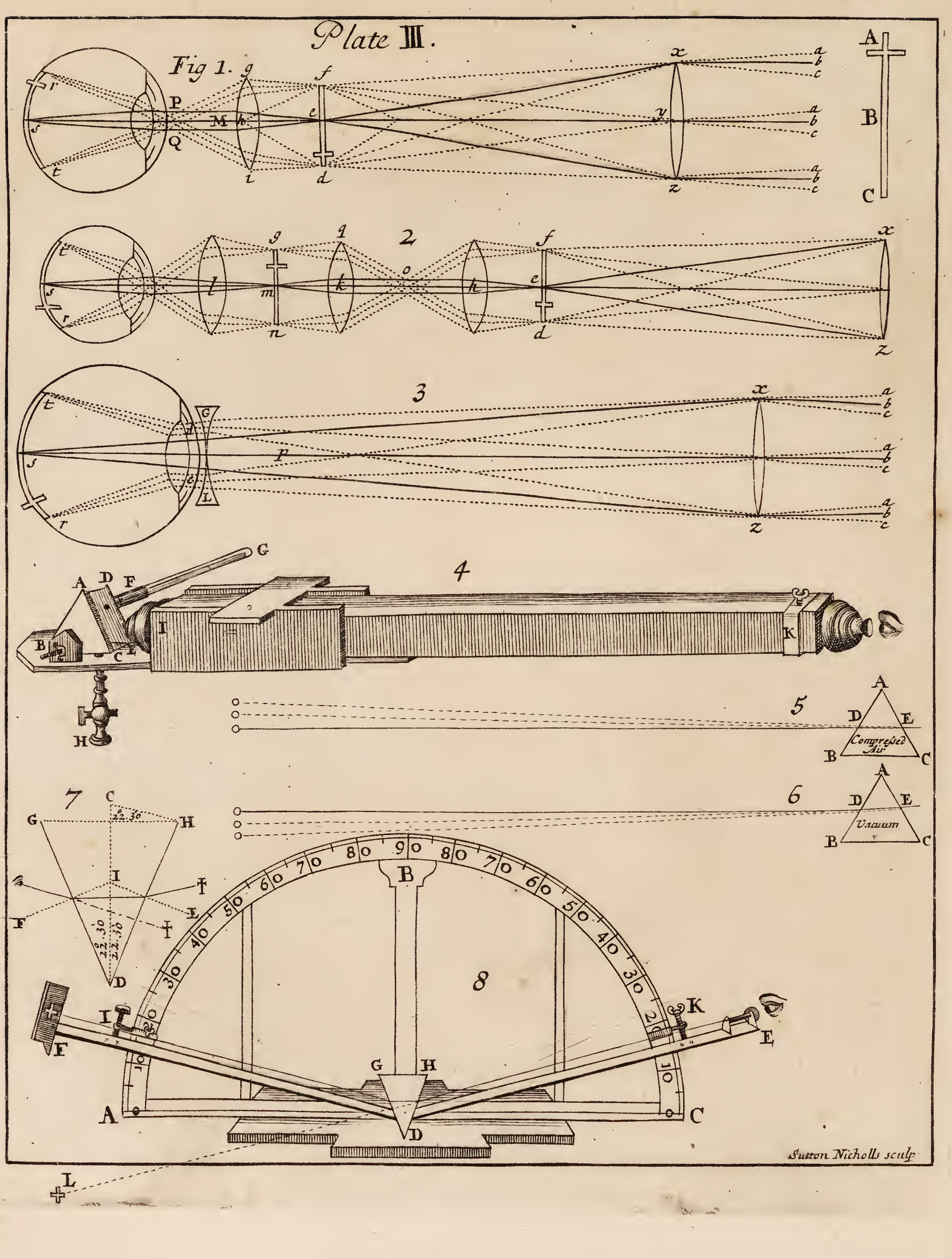
Fig. 11. Shews how a Lens does ſo refract the Rays from every Point of an Object, that is in its Focus C, and B, and A, that the Rays from each of thoſe Points do become parallel afterward; and alſo how parallel Rays of different Poſitions are gather'd in that Focus.

Fig. 12. Is the Nature of direct Viſion by the Eye, in ſome Conformity to the 10th Figure: only in this Caſe the Cryſtalline Humour is the Lens.

Fig. 13. Is the Caſe of a Concavo-convex Glaſs, with its parallel Surfaces, as in *Fig.* 1.

An

Plate III.



Sutton Nicholls sculp.

An Explication of the Third PLATE.

FIGURE 1. Is a Teleſcope, with two Convex Glaſſes, the one towards the Object and the Segments of a great Sphere, the other near the Eye, the Segments of a ſmall Sphere *g h i*, and they are to be ſo placed that the diſtinct Baſe or Image may, by the Collection of the Rays, be in the common Focus of both the Glaſſes *f e d*. By theſe two Glaſſes the parallel Rays, or thoſe nearly ſo, as proceeding from the ſame Point of the Object A B C, (which is to be ſuppos'd conſiderably remote) are made to meet in the intermediate Image *f e d*, at *f*, and *e*, and *d*; and again at the Bottom of the Eye, at *r*, and *s*, and *t*; but in an erect Poſition; and therefore ſo as to ſhew the Object inverted.

Fig. 2. Is a Teleſcope with four Convex Glaſſes, the one towards the Object, and three nearer the Eye: Whoſe Images are made in the common Focus of two Glaſſes, as before. This is like the former; but only that two of the Eye Glaſſes ſerve merely to reinvert, or to erect the Image, that ſo it may be inverted at the Bottom of the Eye; and therefore may ſhew the Object in its true or erect Poſition.

Fig. 3. Is a Teleſcope, with a Convex Object Glaſs, and a Concave Eye Glaſs; which laſt, by ſcattering the Rays, as if they came from a nearer Point, makes the Image inverted in the Bottom of the Eye, and therefore ſhews the Object in its true or erect Poſition. Only this takes in but a ſmall Part of an Object, and ſo is leſs uſed than the two former Teleſcopes.

Fig. 4. Is a Teleſcope with a Triangular Priſm D B in its Axis; and that Priſm's Gage F G for the Demonſtration of the Refraction out of *Vacuum* into Air, and out of thinner Air into thicker; and both by the Means of an Object ſeen through the Priſm, as well when the Air is condenſed, as when it is exhauſted. Where in the firſt Caſe the Object is ſeen higher, and in the other lower than in its natural Situation; as the two following Figures demonſtrate.

Fig. 5. Shews how the Object or Circle which was low at firſt, is to Appearance *rais'd* as it paſſes through condens'd Air; by being refracted towards the perpendicular, in its Ingreſs into a Glaſs Priſm, and from it in its Egreſs into the common Air again.

Fig. 6. Shews how the ſame Object or Circle, which was high at firſt, is to Appearance *depreſs'd*, as it paſſes through the *Vacuum*; by being refracted from the Perpendicular, in its Ingreſs into the Priſm, and towards it, in its Egreſs into the common Air again.

Fig. 7. Is a Triangular Glaſs Priſm, fitted to receive all ſorts of Fluids, and when rightly apply'd to the Semi-circle of the next Figure, does exactly meaſure the refractive Power of all thoſe Fluids. Where the vertical Angle G D H is 45 Degrees; and by conſequence the half Angles CDH, C D G, C H G, are 22° 30′, and where all is to be ſo contriv'd, that the Rays within the Glaſs may be parallel to GH, and perpendicular to CD, and may fall on each ſide Plain of the Glaſs Priſm in an Angle of 22° 30′ from their Perpendiculars; that ſo the Refractions at the Ingreſs and Egreſs may be equal, and the Computations eaſy.

Fig. 8. Is the Semicircle, with the Glaſs Priſm full of its Liquor rightly apply'd thereto; and both Arms of the Index E D, F D, equally elevated above the horizontal Line A C. This ſhews the Proportion of the Sine of the Angle of Incidence to that of Refraction, in this Incidence of 22° 30′; which Proportion of Sines being the ſame in all other Angles, we hence learn that Proportion accurately and univerſally.

Plate IIII.

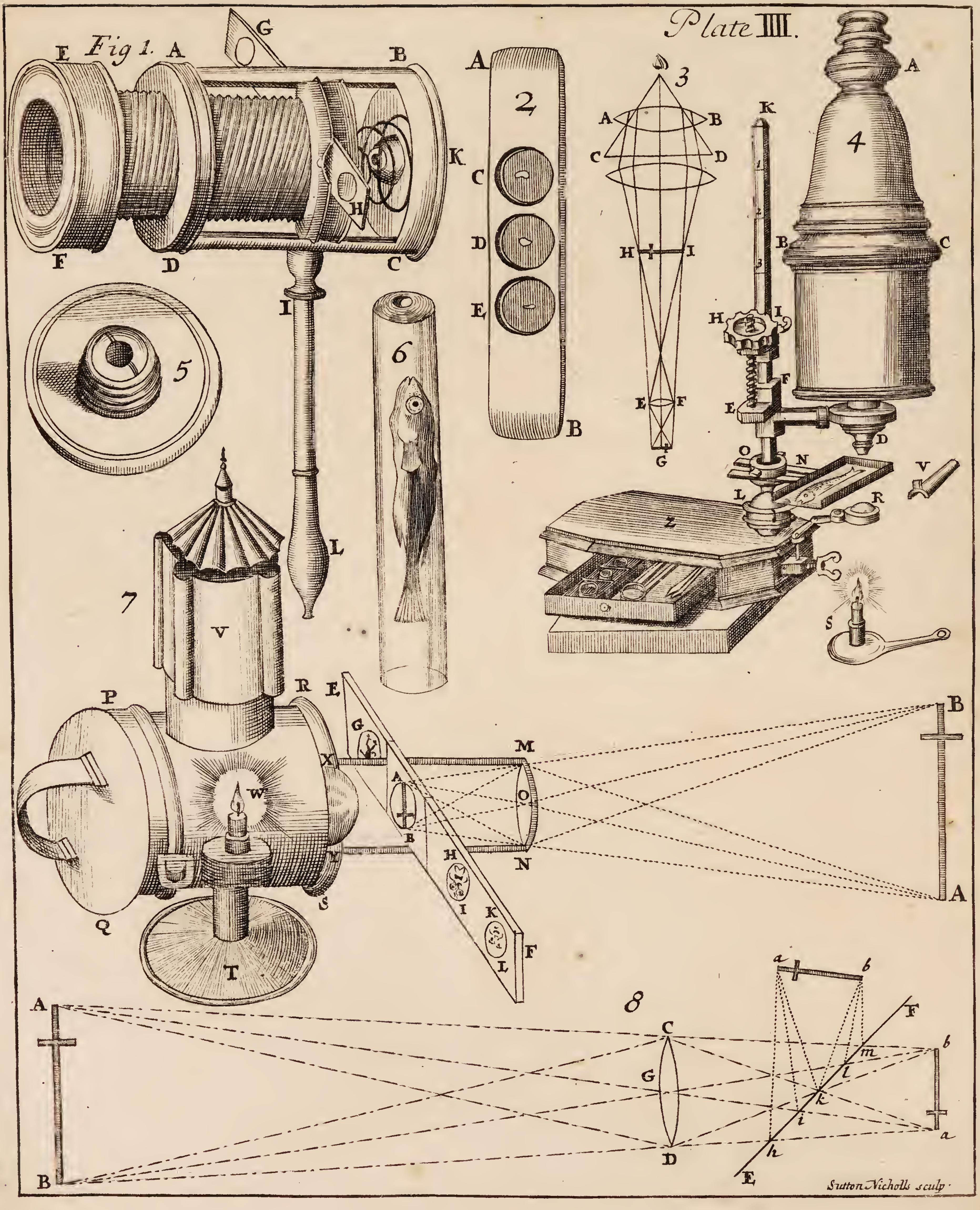


Fig 1.
E A G B K H D F C I L
2
A C D E B
3
A B C D H I E F G
4
K A B C H I F E D O N L V R Z S
5
6
7
V P R E G X M A W O B N Y H I K S Q T F L B A
8
A B C G D a b F m l k i h E b a

Sutton Nicholls sculp.

An Explication of the Fourth PLATE.

FIGURE 1. Is the Apparatus for Microſcopes: Containing A C a Cylinder of Braſs or Ivory; to which, near the Eye at K, the Microſcope it ſelf, or very ſmall Sphere of Glaſs ſet in Ivory, is apply'd; G H a ſmall Slice of Ivory, and its *Muſcovy* Glaſs Circles, with the fine Objects upon them, inſerted in their true Place; E F a Convex Glaſs, ſcrewed into the former Cylinder, and at a due Diſtance caſting Light on the Objects; with I L, the Handle of the Microſcope.

Fig. 2. Is only one of the Slices of Ivory A B, like G H before-mentioned, ſet by it ſelf; with the double Circles of *Muſcovy* Glaſs, and kept down by a circular Wire; between which, on one of thoſe Glaſſes, the ſmall Objects are commonly plac'd.

Fig. 3. Is a Scheme to demonſtrate how the double Microſcope comes to magnify ſo much. Where G is the ſmall Object; which, if there be Light ſufficient, may by the ſmall Microſcope Glaſs E F, placed very near the Object, be caſt into a larger Image H I: Which by the Means of the two Eye Glaſſes, are reduc'd into a Compaſs fit to enter into the Eye. And here by the way it is to be noted that the ſmall Glaſſes, whereby ſingle Microſcopes do magnify ſo much, and whereby the Magnitude is in Part increas'd in this double Microſcope, is only a very ſmall ſpherical Glaſs, or Segment of it, which does ſo ſuddenly reduce diſtant Rays to Paralleliſm, or nearly to it, that a ſmall Object, which by its great Nearneſs could not be otherwiſe ſeen, is hereby made viſible.

Fig. 4. Is the double Microſcope, with all its Apparatus and Contrivances, as to the Poſition of the Object, the Light to be thrown upon it, and the Elevation and Depreſſion of the Inſtrument it ſelf, as the Caſe requires, *&c.* all which the Figure does plainly ſhew to the Eye.

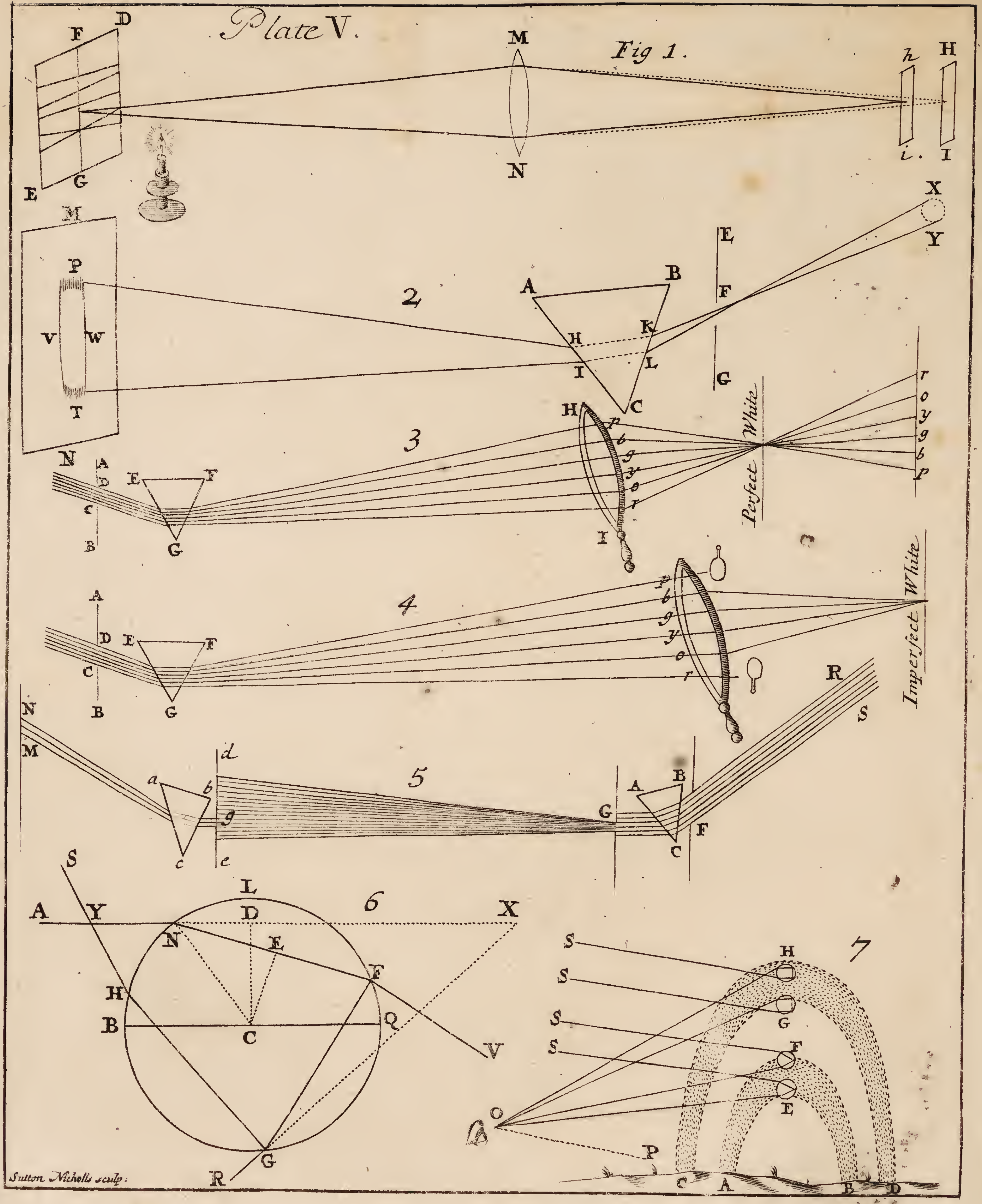
Fig. 5. Is a circular Plate of Ivory, with a ſmall Sphere of Glaſs in its Center, and a Screw round the Center, to be put upon the firſt Figure at B C, as a ſingle Microſcope.

Fig. 6. Is a ſmall Fiſh, repreſented in a Cylindrical hollow Glaſs, ſo as it is to be placed when the Circulation of Blood in its Tail is to be ſeen by the ſingle Microſcope.

Fig. 7. Is the Magick Lanthorn, with its Pedeſtal T: its Lamp W; its double Convex Glaſs X Y; its Pictures inverted upon the Plate E F; and its large or gygantick Images at B A projected upon the white Wall, to the Surprize of the Spectators.

Fig. 8. Is the Demonſtration of the *Camera obſcura*, or dark Chamber; which will ſhew the Object as A B erect. Where C D is the double Convex Glaſs, ready to form an inverted Picture *b a*: Which by the Reflection of the plain Speculum EF, plac'd obliquely in an Angle of 4°, is formed in an erect Poſition at *a b*, for the View of the Spectator.

Plate V.



Sutton Nicholls sculp:

An Explication of the Fifth PLATE.

FIGURE 1. Is one of Sir *Iſaac Newton*'s Experiments, to ſhew the different Refrangibility of the Rays of Light, of the different Colours, Red, Orange, Yellow, Green, Blue, Indigo, Violet. Where D E is a Parallelogram of Paſtboard, having the one half D G blue, and the other half F E red; both ſtrongly illuminated by the ſame Candle: and having black Silk wrapped ſeveral times round it. M N is a Lens or double Convex Glaſs interpos'd, which gathers upon white Paper the blue Rays ſooner at *h i* than the Red at H I: As appears by the Diſtinctneſs of the Colours and of the Silk at thoſe and only thoſe Diſtances. Where alſo at ſomewhat above 12 Feet from the Colours to the Images, the Diſtance between *h i* and H I is no leſs than an Inch and half.

Fig. 2. Is another of Sir *Iſaac*'s Experiments to the ſame Purpoſe: Where X Y repreſents the Sun: E G, a Window, with a ſmall round Hole at F: within which is a Triangular Glaſs Priſm A B C, by which the Rays of the Sun are differently refracted upon a white Wall or Paper M N; and become an Oblong Image P T; the Violet ſeen at P as moſt refracted; and the Red at T, as leaſt refracted: And the intermediate Colours ſeen in intermediate Places, according to the different Degrees of their Refraction.

Fig. 3. Is another of his Experiments, to ſhew that White is a Mixture of all Sorts of colour'd Rays; where D C is a Hole in the Window, which admits the Sun's Rays. E F G a Priſm, caſting its oblong colour'd Image upon a Lens, or double Convex Glaſs; which collects all thoſe Rays into its Focus. In which Caſe, the Point of Concourſe exhibits a perfect White Colour; tho' upon their Separation again, the oblong colour'd Image appears again, only in an inverted Poſition: as the croſſing of the Rays in the Focus muſt of Neceſſity occaſion.

Fig. 4. Is the laſt Experiment improv'd; by ſhewing that the White Light made by the Mixture of all the Colours is but imperfectly ſo, when any of the ſeveral Colours are intercepted in their Paſſage to their Focus, or Place of Mixture.

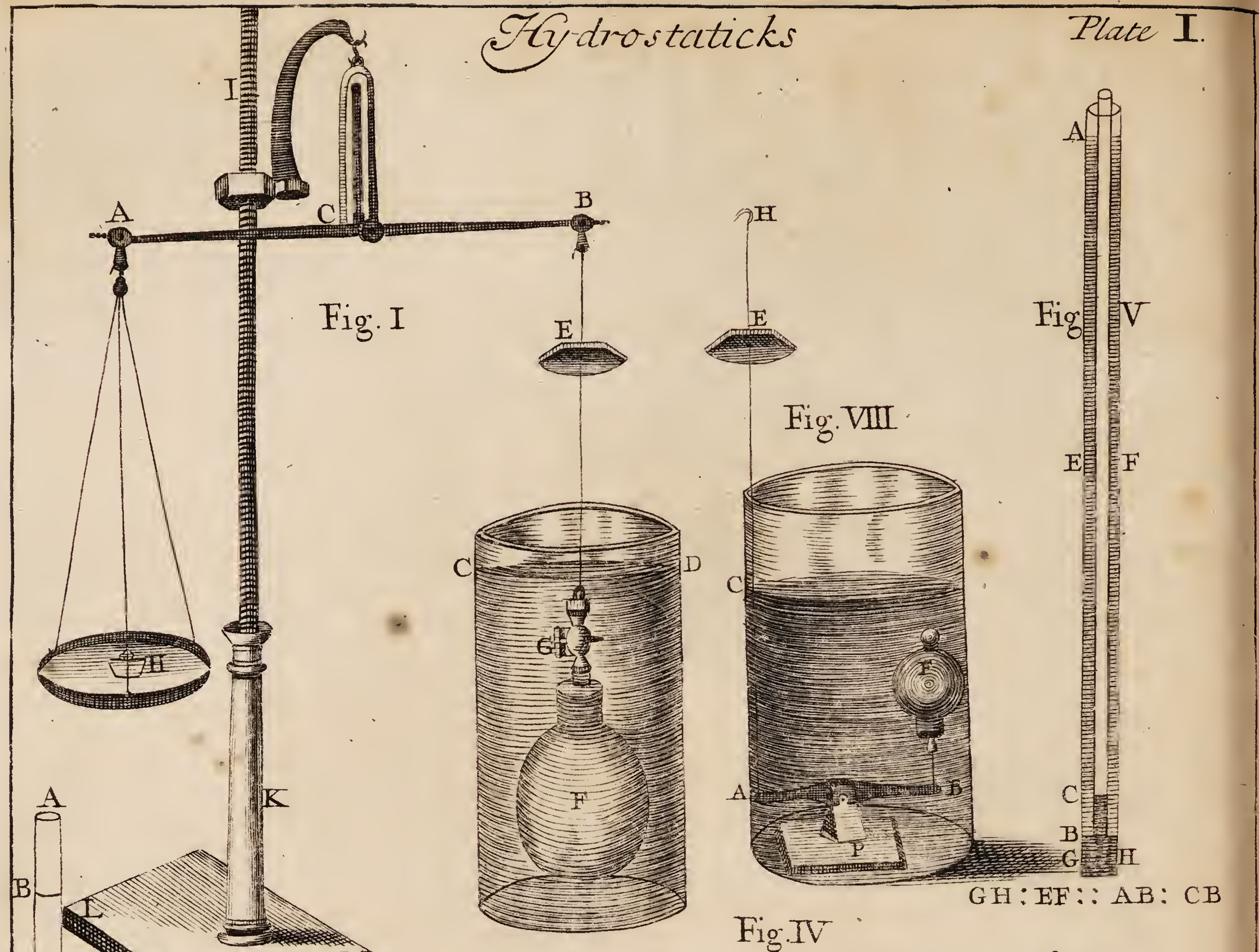
Fig. 5. Is the *Experimentum Crucis*, or determining Experiment. Where B F is the Hole that lets in a large Ray of Light: whoſe middle Part, after it has paſs'd through the Priſm A B C, is let through a leſſer Hole at G, and forms an oblong colour'd Image at *d e*: where another ſmall Hole lets thro' one Colour only; which paſſing through the Second Priſm *a b c* it is refracted again, and caſt upon N M. And here it is moſt remarkable, that the two Holes and ſecond Priſm are kept immoveable; and ſo the Rays G *g* fall upon the ſecond Priſm in the very ſame Angle, whatever Colour they are of, and that by the Motion of the firſt Priſm, all the Colours may ſucceſsfully paſs through the ſame Holes. Yet is the Refraction by the ſecond Priſm never then able to produce any Variety of Colours; but exhibits the Image always of that Colour alone, which falls upon it before the ſecond Refraction.

Fig. 6. Is a Figure for the Explication of the ſeveral Refractions and Reflections of Light, which cauſe the *Phænomena* of the Rainbow. Thus if the greateſt Crowd of Rays enter in Parallel to B Q along or near to A N, the round Drop of Water LBGQ will refract Part of thoſe Rays to F, whence Part of them will be reflected to G: And going there out of the Drop, will be thereby refracted to R, which double Refraction will ſo ſeparate the ſeveral Colours, and make them go out in Angles ſo ſenſibly different, that as the Eye is placed a little higher or lower, it will ſee a different Colour; and that in Angles as AXR, of about 41 Degrees; and this is the Caſe of the primary Rainbow, which appears in about that Angle from the Axis B Q, or its Parallel A X. Thus alſo, if the ſame Line A N be now ſuppos'd to repreſent another Drop, and that ſome of the Rays at G are reflected a ſecond time, and ſo paſs out at H, and are there refracted to S; here will be a weaker Impreſſion, but a like Refraction and Separation of the Colours as before; and the Eye placed a little higher or lower will alſo ſee different Colours, tho' in a contrary Order to the former; and that in an Angle, as A Y S, of about 52 Degrees and a half; which is the Caſe of the ſecondary Rainbow.

Fig. 7. Are the two Rainbows themſelves, repreſented as they appear in Nature. Where A E B F repreſents the Air full of ſpherical Drops of Rain, in ſuch Parts as the Angles EOP, FOP are about 41 Degrees from the Axis O P, which Axis is the Line from the Sun's Center, through the Eye of the Spectator, to the Center of the Rainbow: And where C G D H repreſents the ſame Air, full of the like Drops, in ſuch Parts where the Angles GOP, HOP are about 52 Degr. and a half. Where alſo the Rays SE, SF, SG, SH, coming from the Sun's Center, are repreſented as parallel, by reaſon of its vaſt Diſtance. Theſe Rays, when they fall upon the higher Quadrant of the Drop, as at S E, S F, come to the Eye at O in about an Angle of 41 Degrees, after two Refractions, and one Reflection; and ſo cauſe the primary Rainbow: the Red is without, by the leaſt refrangible Rays at F: and the blue within, by the more refrangible Rays at E. But when they fall upon the lower Quadrant of the Drop, as at SG, SH, they come to the ſame Eye at O, but in an Angle of about 52 Degrees and a half, after two Refractions, and two Reflections, and ſo cauſe the ſecondary Rainbow. Which is Blue without, by the more refrangible Rays at H; and Red within by the leaſt at G. Where note, that becauſe the Angles FOP, EOP, as well as thoſe HOP, GOP, are ever the ſame, the ſame Colours muſt ſtill be circular, or appear in the Surface of a right Cone, whoſe Axis is O P, and whoſe Sides are the Lines turned round thereon, as OE OF, and OG OH.

Hydrostaticks

Plate I.



I. Senex ſculpt.

HYDROSTATICKS.

An Explication of the Firſt Plate.

FIGURE 1. Is a Balance, to weigh Water in its own Element, and in the Air; and to prove that its Weight is the very ſame in the former Caſe as in the latter. For when the Glaſs Bottle F is exhauſted of Air, it will indeed require much more Weight to counterpoiſe it in the Air, than in the Water; by Reaſon of the much greater Weight of the Water thruſt out by it, than of the Air; yet when upon the Admiſſion of Water within, you weigh it again in the Air, and then in the Water, the additional Counterpoiſe now neceſſary is the very ſame; and ſhews that the real Weight of the Water admitted, is the ſame in both Elements. This Figure does alſo ſhew how Trials may be made to ſhew the reſpective Weight of thoſe Bodies in Fluids that ſink in them.

Fig. 2. Is an inverted Syphon, to ſhew why Fluids ever preſs according to perpendicular Altitude, and not according to Quantity of Matter: As the ſmall Quantity of Water in the ſmaller Tube is a Balance for the great Quantity in the greater, and ſtands upon the ſame Level C D E G; becauſe in all poſſible Motions and Vibrations of the Fluid, the Velocity in the ſmaller muſt, by the Make of the Syphon, compenſate the Quantity in the larger; the one aſcending or deſcending as far as BD, while the other aſcends only as far as E H, and ſo the Force is equal on both Sides, as is the known Caſe in the Stiliard alſo.

Fig. 3. Is to ſhew the ſame equal perpendicular Height or Level in a common Syphon inverted.

Fig. 4. Is a Number of hollow Tubes, of all Shapes and Directions, to ſhew that if their lower Orifices be put under tinged Water, and Oil be poured on the Surface of that Water, from G H to EF, the tinged Water will equally be preſſed upwards through all the Tubes, according to all Directions; and will ſtand upon a common Level; tho' ſomewhat under the Surface of the Oil, becauſe Oil is lighter than Water.

Fig. 5. Is for the ſame Experiment with Water on the Surface of Quickſilver; into which Quickſilver a hollow Tube is inſerted before the pourings in of the Water. For the Water will preſs upon the Quickſilver, and raiſe it in the ſmall Tube, till it bears the ſame Proportion to the Height of the Water, that the ſpecifick Gravity of Water bears to that of Quickſilver, or about a fourteenth Part ſo high. Which, by the by, is one ready Way alſo of finding the Specifick Gravity of Quickſilver to Water, by meaſuring their ſeveral Altitudes.

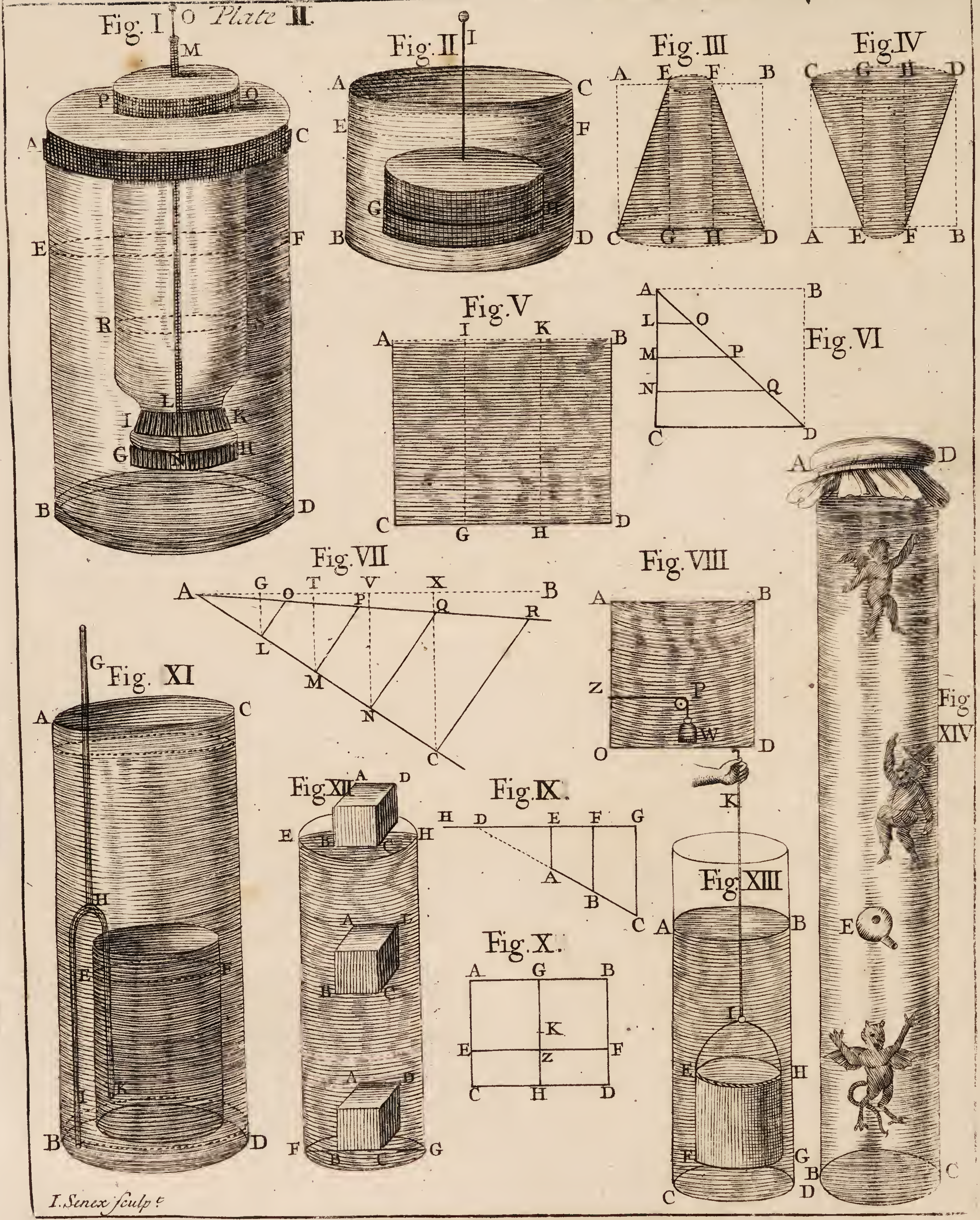
Fig. 6. Is to ſhew how Water in a very ſmall Tube may elevate Quickſilver it ſelf, when it is thruſt more below the Surface of the Water, than the Difference of their Specifick Gravity requires; and that it will riſe or fall as you thruſt it lower, or raiſe it higher; and will at laſt fall out at the Bottom, if you raiſe it too high.

Fig. 7. Is to ſhew that Fluids of different Specifick Gravities, as Water A B, and Oil A C, will ſtand at unequal perpendicular Altitudes, in Proportion to their Quantities, and Difference of Specifick Gravities.

Fig. 8. Is a Part of a Compound Balance, to be joined to that of *Fig.* 1. for the weighing of Levity, or of the Power of Aſcent in a Body, as F, lighter than the Fluid wherein it is; and will ſhew that that Levity is the Difference of the Weight of that Body, and of an equal Bulk of the Fluid: Which is alſo the reſpective Gravity of thoſe Bodies which are heavier than their Fluids, as may be tried by the ſame Balance of *Fig.* 1. alone.

An

Plate II.



I. Senex sculp^t

An Explication of the Second PLATE.

FIGURE 1. Is a large Glaſs Veſſel A D full of Water as high as E F. Within this is a leſſer Glaſs Veſſel P H, open at both Ends, but ſomewhat narrower at the Bottom. Through the middle of this goes a ſtrong Wire M N, to which is fixed at the lower End a Plate of Lead G H, with wet Leather to its upper Surface, to be applied to the large lower Orifice of the leſſer Glaſs I K, to keep out the Water from entring into the ſame any otherwiſe than by a ſlow Inſinuation. This is to ſhew that a Plate of Lead, or other Metal, may be ſupported by Water, and not ſink in it, where the Water is kept from preſſing on its upper Surface, ſo long as its Depth under the Water is greater than its Specifick Gravity requires; and that by Conſequence while Water is gradually admitted over it, it will not ſink till the perpendicular Height of the Column of Air between E F and R S bears no greater Proportion to the Thickneſs of the metalline Plate (with what is annexed to it) than the Specifick Gravity of the Metal bears to Water.

Fig. 2. Is a cylindrical Vial or Glaſs A D, with a ſmall Cylinder of Wood below G H fixed to its Bottom, and made very ſmooth at Top; and another like Cylinder of Wood above G H, made equally ſmooth on the lower Side, that it may as exactly as poſſible fit the other; with a ſtrong Pin I, fixed in its Axis. Upon theſe Two, when laid cloſe, is pour'd Quickſilver, till it covers them both as far as E F. This is to ſhew, that there is no ſuch thing as poſitive Levity; but that Wood is ſo far from riſing in Quickſilver of it ſelf, that till a ſufficient Force pulls it up, and permits the Quickſilver to inſinuate between the two Plates, the upper is faſtned to the lower by that Quickſilver: Tho' upon the firſt Inſinuation of the ſame it immediately and violently emerges of it ſelf: As Dr. *Moor*'s Famous Trencher did in his Bucket, to his great Surprize; till he was forc'd to ſolve it by the Introduction of his Spirit of Nature.

Fig. 3, and 4. Are Veſſels of equal Altitude, but unequal Baſes, and of the ſame Quantity of Water; to ſhew that Fluids ever preſs according to their Baſes, if their perpendicular Height be equal; and according to their perpendicular Height, if their Baſes be equal, whatever Figure they are of.

Fig. 5. Is a cubical Veſſel full of Water, in order to compute the entire Quantity of the Preſſure its Sides and Bottom ſuſtain. And that the Bottom alone ſuſtains the whole Weight of the Water; as is moſt evident.

Fig. 6. Is to ſhew that each Side of the ſame Veſſel ſuſtains a Preſſure equal to half the Weight of the ſame Water. For ſince the Preſſure at every Point, as L, M, N, C, is equal to the Altitude of the Water above it, A L, A M, A N, A C, by erecting equal Perpendiculars L O, M P, N Q, C D, and ſo at all the intermediate Points, and ſumming them up, we ſhall have the Triangle A C D as the Sum of all the Preſſures; which being half the Square A C D B, made by as many Perpendiculars equal to the longeſt C D, and bearing the whole Weight of the Square over it A C D B, ſhews that the Preſſure on every phyſical Line, as A C of a triangular Priſm, and ſo on the whole Side repreſented by it, is one half of the whole Water. So that ſince each of the four Sides ſuſtain half, and the Bottom the whole Weight notwithſtanding, the entire Preſſure is three times the Weight.

Fig. 7. Is a like Method of Computation for an inclined Plain's Preſſure, and how to eſtimate it; *viz.* by the Weight of Water equal to the Priſm repreſented by the Triangle A R C, where the Lines L O, M P, N Q, C R, are erected perpendicular to A C, and equal to L G, M T, N V, C X, reſpectively.

Fig. 8. Is to determine the Center of Preſſure Z againſt ſuch a Plain; at which if an equal Weight W directly pulls along Z P over the Pulley P, it will juſt balance the Water, and evenly ſuſtain its Preſſure.

Fig. 9. Is to ſhew that this Center of Preſſure is no other than the Center of Percuſſion or Oſcillation about an Axis, as D. For the Preſſures being as the Perpendiculars E A, F B, G C; and the Percuſſions, as D A, D B, D C, the Radij of the Circles of Motion; and E A being to F B, as D A to D B; and F B to G C, as D B to D C: The Percuſſions are ſtill as the Preſſures; and ſo the Center of Percuſſion, the ſame with the Center of Preſſure.

Fig. 10. Is for the Computation of the Quantity and Center of the Preſſure on any erect Rectangle under Water; according to that Rule, that the Depth of any Bodies or Surfaces Center of Gravity is to be taken for the perpendicular Altitude of all the Preſſures, as a Mean between them.

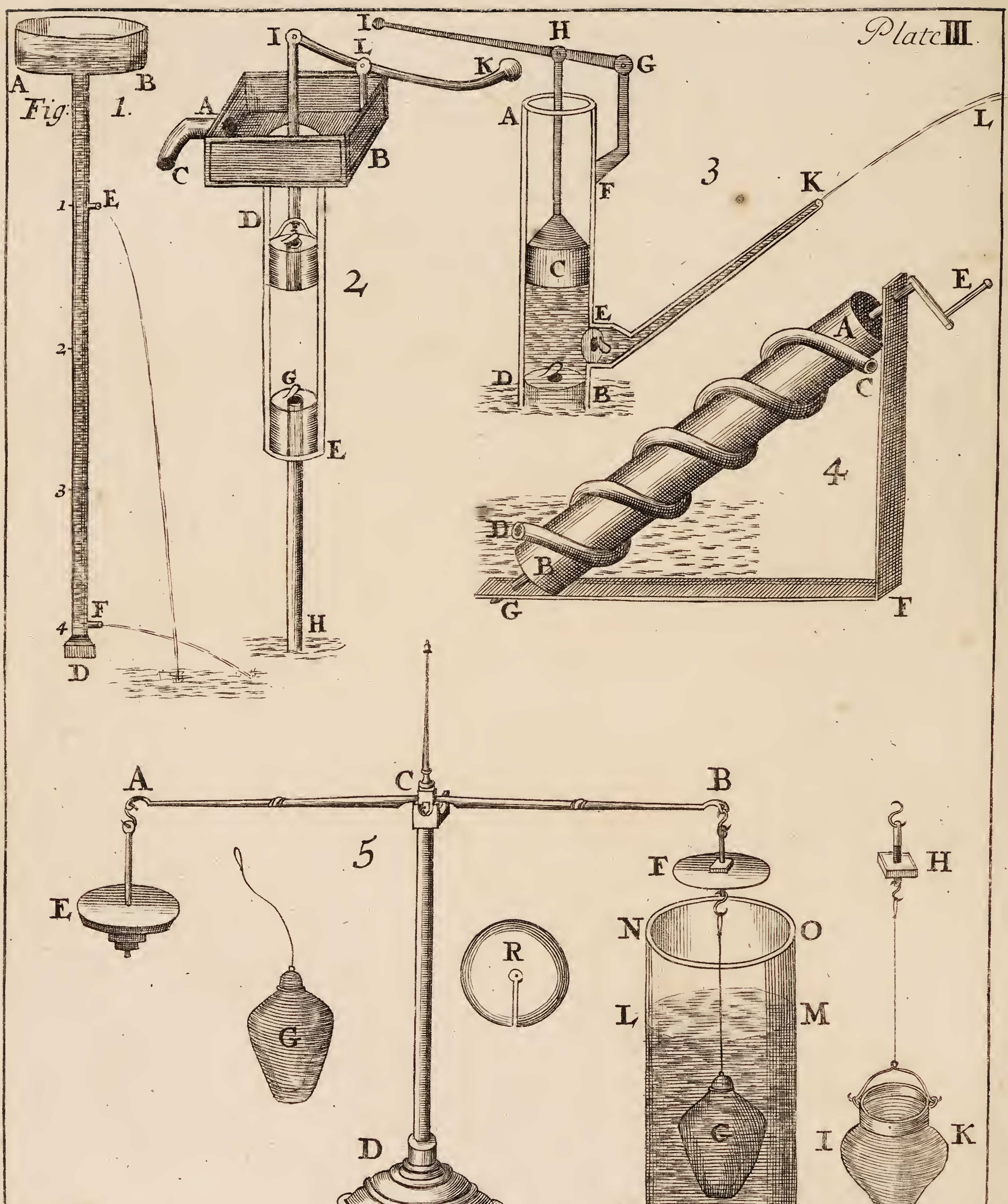
Fig. 11. Is a large Glaſs Veſſel A D, containing Water near the Bottom; with another ſmaller Veſſel F K with Water almoſt to its Top. There is alſo a Syphon B H K, with an hollow Stem G H, communicating with both its Legs. To ſhew that if you ſtop the Top of the Stem of the Syphon while you pour Oil into both Veſſels, a conſiderable Height above the Bend of the Syphon, and then unſtop it, the Oil will preſs upon the Water in both Veſſels, and force it to aſcend in each Leg; till meeting at the Bend, it run down the longer Leg, out of the higher Water into the lower. This is to ſhew how the Air preſſing upon Water may raiſe it up, and cauſe the known Effects of Syphons, Pumps, Syringes, *&c.* Which uſed to be aſcribed to Nature's Abhorrence of a *Vacuum*.

Fig. 12. Is a Cube at different Depths of the ſame Water; to ſhew how it muſt have the ſame Weight in one Place that it has in another, becauſe the Water and Cube have ever the ſame Proportion of Bulk and Gravity to one another.

Fig. 13. Is a Bucket under Water; to ſhew it can have there no reſpective Gravity, or cannot preponderate; tho' it has ever the ſame abſolute Gravity.

Fig. 14. Are a Bubble and Images of the ſame Nature, made of Glaſs, Air, and Water; all ſo nicely pois'd, that by the Preſſure or Relaxation of the Air included, which is done at the Bladder A D, the Bubble and Images riſe and fail after a ſurprizing Manner.

Plate III



Sutton Nicholls sculp.

An Explication of the Third PLATE.

FIGURE 1. Is a Tube full of Water, with Two Holes E, F, for the Water to run out at, the one F four times as much below the Surface of the Water A B as the other; (the Veſſel to be ſtill kept equally full all along:) to ſhew that the Velocity and Quantity of Fluids that run out, are in only a ſubduplicate Proportion of the Altitude of the Fluids, or twice ſo much in a Fourfold Altitude. Nor can it be otherwiſe: For twice the Quantity running out, with twice the Velocity, implies the Force or Preſſure to be Fourfold, as the Fourfold Altitude requires; and ſo for ever.

Fig. 2. Is a Pump; where G H is a hollow Cylinder, reaching to the Water below, with a Valve G, which will be lift up by the aſcending Water, and permit its Entrance into the Body of the Pump; but will not permit its Return when it is attempting to deſcend. D is the Sucker, with its hollow Cylinder, and a like Valve: which Sucker is pulled upward or thrnſt downward by the Handle I L K. When it is pulled upward, it leaves the Body of the Pump a Vacuum: whence the Air's Preſſure on the Water's Surface below raiſes it up into that Space, and fills it; and when it is thruſt down, the Water, which is ſtopp'd by the lower Valve from going back, is forc'd through the Valve in the Sucker D, into the Ciſtern above; whence by its own Gravity it runs out at the Canal A C.

Fig. 3. Is a Forcing Pump, in the main made like the other, only without a Ciſtern; and the Exit is out of the Side through a Hole, with a Valve opening outward, but ſhutting inward, in which the Sucker when thruſt downwards forces the Water out ſideways with great Violence.

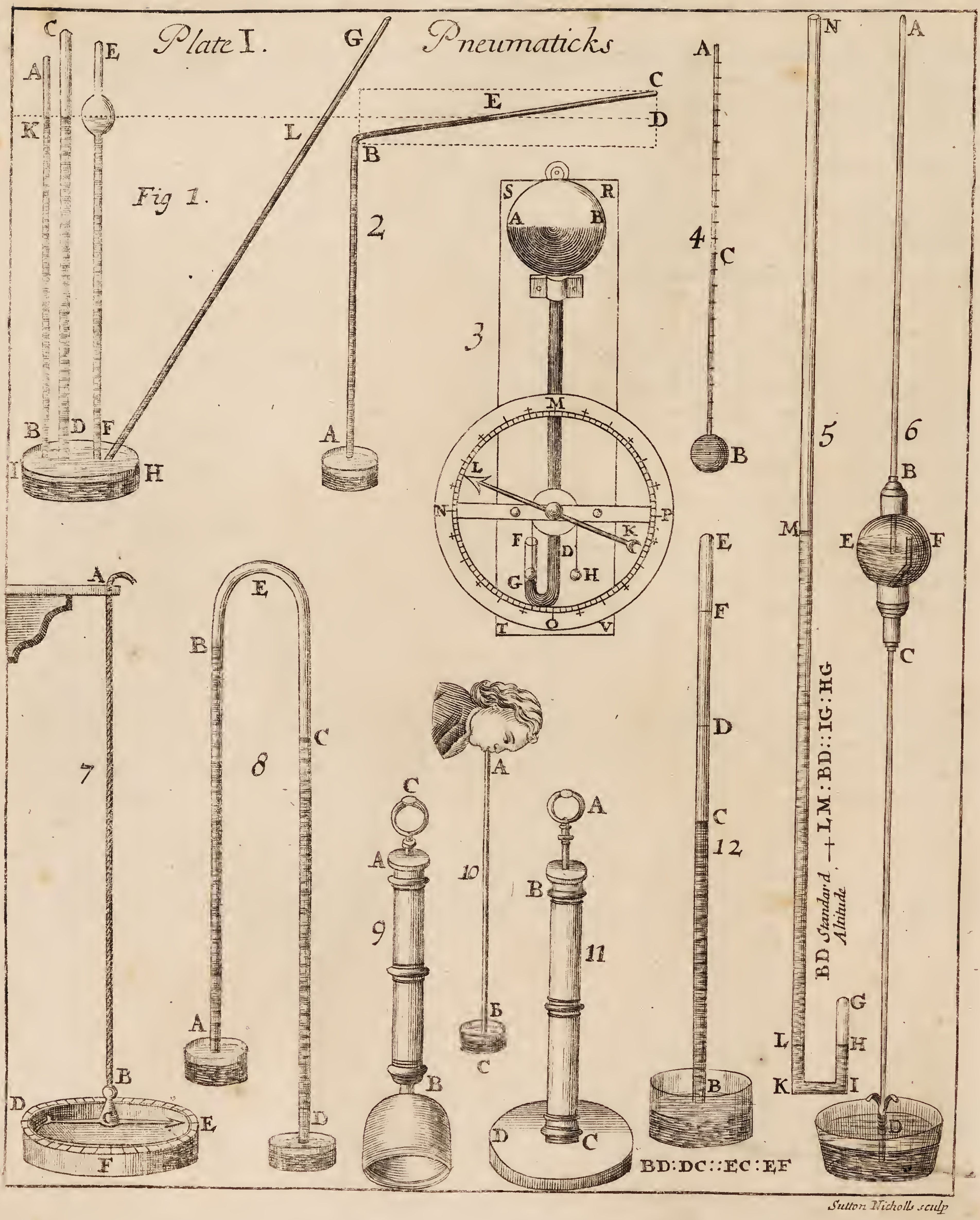
Fig. 4. Is *Archimedes*'s Spiral Pump C D, made of only a Cylinder, with a hollow Spiral Tube wreath'd about it; where the Fluid partly deſcending, and partly aſcending, all the way, makes its flowing along the more eaſy, till upon its Arrival at the Top it runs out at C.

Fig. 5. Is the whole Apparatus of the Hydroſtatical Balance. The Glaſs Bubble G is heavier than all Fluids but Quickſilver, and is to be put into all thoſe Fluids: The Bulk of Water in ours is 830 Grains *Troy*. If when pois'd in Water it ſink more by any Number of Grains, that Number of Grains ſubſtracted from; if leſs, added to thoſe 830, do by their Proportion to 830 give the Specifick Gravity of all ſuch Fluids to Water. I K is the Glaſs Bucket, which in Air is in Æquilibrio with the Scale E: And becauſe when it is let into Water, it will be no longer an Equipoiſe to the oppoſite Scale, but lighter; the Scale R is to be added to the Part H, by which the Bucket is ſuſpended, and that will reſtore the Æquilibrium in Water. By this Solids and Quickſilver are weighed firſt in Air, and then in Water: The Difference of which Weights being the Weight of an equal Bulk of Water, by its Proportion to the firſt Weight in Air, gives the Specifick Gravity of the Solid compared with Water: And if that Difference ſtill divide the Weight in Air, for all ſort of Bodies, we may have a Table of the Specifick Gravities of the Solids; as by dividing 830 by the Sum or Difference of the other Fluids, we may have a like Table of the Specifick Gravity of Fluids, ſuch an one as here preſented the Reader.

A TABLE of the Specifick Gravities of ſeveral Solid and Fluid Bodies.

FINE Gold	19,640
Standard Gold	18,888
Quickſilver	14,000
Lead	11,325
Fine Silver	11,091
Standard Silver	10,535
Biſmuth	9,700
Copper	9,000
Caſt Braſs	8,000
Steel the ſame Piece: Soft	7,738
Hard	7,704
Spring Temper	7,809
Iron	7,645
Tin	7,320
Glaſs of Antimony	5,280
A Pſeudo Topaz	4,270
A Diamond	3,400
Clear Cryſtal Glaſs	3,150
Iceland Cryſtal	2,720
Fine Marble	2,700
Rock Cryſtal	2,650
Common Green Glaſs	2,620
Stone of a mean Gravity	2,500
Sal Gemmæ	2,143
Brick	2,000
Nitre	1,900
Alabaſter	1,875
Dry Ivory	1,825
Brimſtone	1,800
Dantzick Vitriol	1,715
Allom	1,714
Borax	1,714
Calculus Humanus	1,700
Oyl of Vitriol	1,700
Oyl of Tartar	1,550
Bezoar	1,500
Honey	1,450
Gum Arabick	1,375
Spirit of Nirre	1,315
Aqua Fortis	1,300
Serum of Human Blood	1,190
Pitch	1,150
Spirit of Salt	1,130
Spirit of Urine	1,120
Human Blood	1,040
Amber	1,040
Milk	1,030
Urine	1,030
Dry Box-Wood	1,030
Sea-Water	1,030
Common Water	1,000
Camphire	0,996
Bees-Wax	0,955
Lynſeed Oyl	0,932
Dry Oak	0,925
Oyl Olive	0,913
Spirit of Turpentine	0,874
Rectified Spirit of Wine	0,866
Dry Aſh	0,800
Dry Maple	0,755
Dry Elm	0,600
Dry Firr	0,550
Cork	0,240
Air	0,001 $\frac{1}{4}$

Plate I. Pneumaticks



Sutton Nicholls sculp

PNEUMATICKS.

An Explication of the Firſt PLATE.

FIGURE 1. Are ſeveral Torricellian Tubes or Barometers of different Shapes, Bores, and Poſitions; but where the perpendicular Altitude of the Quickſilver in the Tubes, above the Level of the Surface of that in the Baſon, is ever the ſame, or between 28 and 31 Inches high; which is the known Counterpoiſe to between 32 and 36 Feet of Water; and to the entire Atmoſphere in its ſeveral States and Elevations, where the Baſes of the ſeveral Tubes are ſuppoſed equal.

Fig. 2. Is a Diagonal Barometer, where the Alteration of the Perpendicular Altitude of 3 Inches, by the Obliquity of that Part BC of the Tube ABC, (as a Diagonal is oblique to the Sides of its Parallelogram,) is increas'd to 20 or 30 Inches Sideways, for more Nicety of Obſervation.

Fig. 3. Is a Wheel Barometer, where by two Weights G and H on a Pulley, by which a Hand is turned, the one of which plays freely in the Air, and the other riſes and falls with the Quickſilver in the Tube, the Diviſions are larger and more obvious than in the ordinary Barometer: as they are in the Diagonal one; for the like greater Nicety of Obſervation.

Fig. 4. Is a common Thermometer, to determine the Quantity of the Heat of the Air, or of any Liquor, by the Rarefraction of Spirit of Wine contain'd in the hollow Ball at the Bottom, and its conſequent aſcending to the ſeveral Diviſions on the ſmall Tube.

Fig. 5, and 12. Are to ſhew that the Air's Denſity is as its Compreſſion, the former upon a greater Compreſſion, and the latter upon a greater Rarefraction; and that accordingly, in the firſt Caſe, BD the Standard Altitude, or about 29 ½ Inches, and L M the Additional Altitude of Quickſilver pour'd in higher than the Level H, taken together, is to BD the Standard Altitude alone, as IG the inverted Part of the Tube when full of common Air, to HG the Part full of condens'd Air: And in the Second Caſe, B D the Standard Altitude, is to D C the Depreſſion by the Air, as E C the Part of the Tube full of the expanded Air, to E F the Part at firſt left full of common Air.

Fig. 6. Is Monſieur *Azout*'s noble Experiment, to determine, that 'tis certainly the Air's Preſſure that raiſes the Quickſilver in the Barometer. The Inſtrument is nothing but a double Barometer communicating together, by the Means of a ſmall hollow Pipe in the Middle: Its lower Tube is ſtopp'd at the Bottom with a Bladder; and when the entire Cavities are full of Quickſilver, the Bladder is prick'd or cut, and the Quickſilver runs out: Hereupon the upper Barometer's Tube, and Part of its Baſon, becomes empty; while the lower is yet full: But upon the unſcrewing a Screw, and letting Air in above the upper Baſon, that Air preſſes on the Quickſilver's Surface, and raiſes it into its Tube; while the ſame Air preſſing down the upper Part of the under Tube, depreſſes the Quickſilver therein at the ſame time.

Fig. 7. Is a Hygrometer, or Cord, with a Needle or Index in a Circle, to meaſure the Air's Moiſture by its ſhrinking up, and conſequent Revolution one way; and the Air's Dryneſs, by its Extenſion down, and conſequent Revolution the contrary way; and both meaſured by the Degrees of the Bottom Circle.

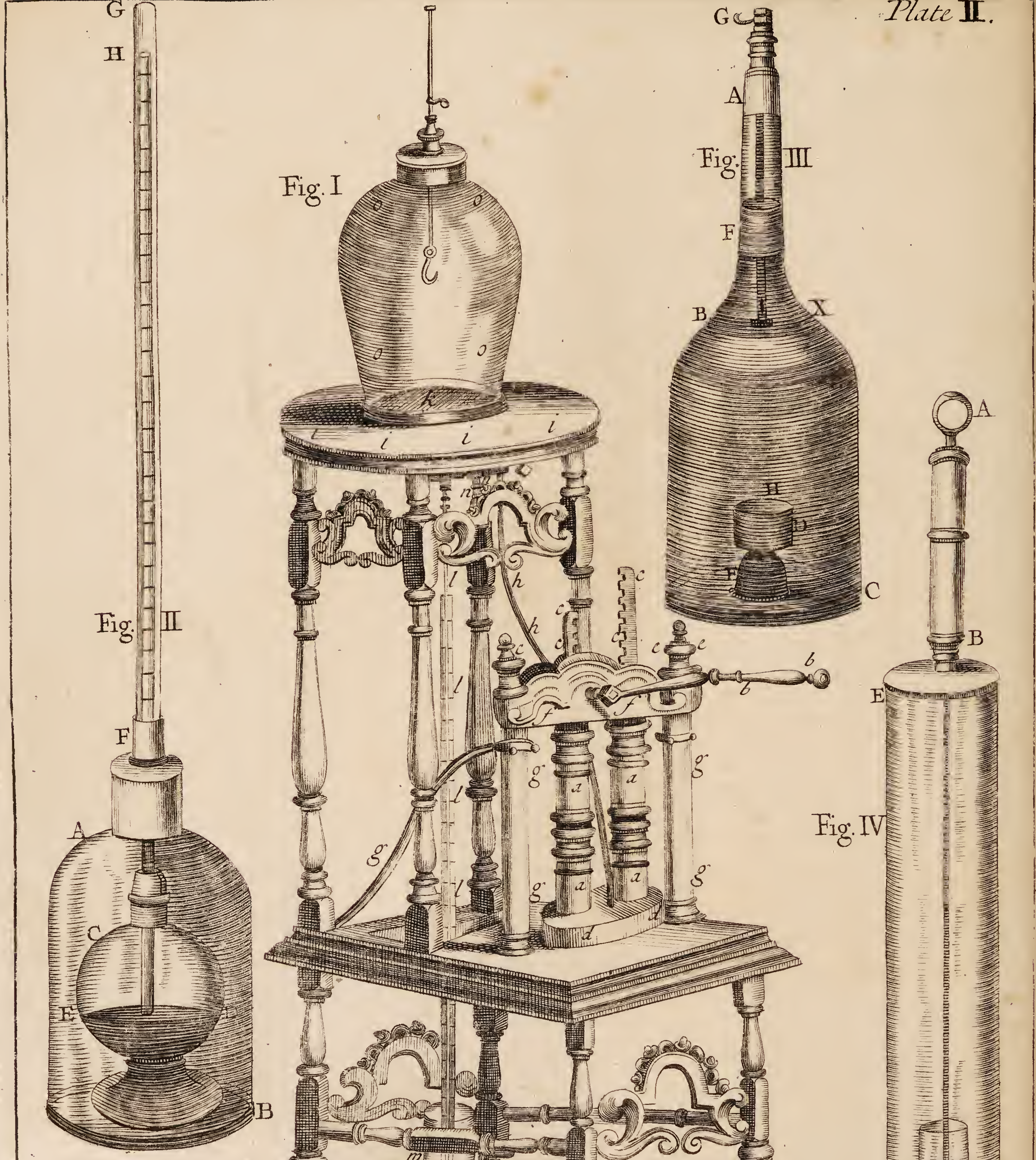
Fig. 8. Is a Syphon above 29 ½ Inches high, along where no Suction nor Art can make the Quickſilver run, as it uſes to do when it is of any leſs Altitude.

Fig. 9. Is the new Sort of Cupping-Glaſs, whence the Air is ſuck'd out by a Syringe, and where by a Valve it is hindred from returning.

Fig. 10. Is an Example of Suction; and will ſhew that Quickſilver can thereby never be rais'd to 29 ½ Inches.

Fig. 11. Is an Example of a Weight raiſed by a Syringe, as Water uſes to be; and ſtill ſhews, that all is proportionable to the Power of the Air's Preſſure, and is limited thereby.

Plate II.



I. Senex sculp^t.

An Explication of the Second PLATE.

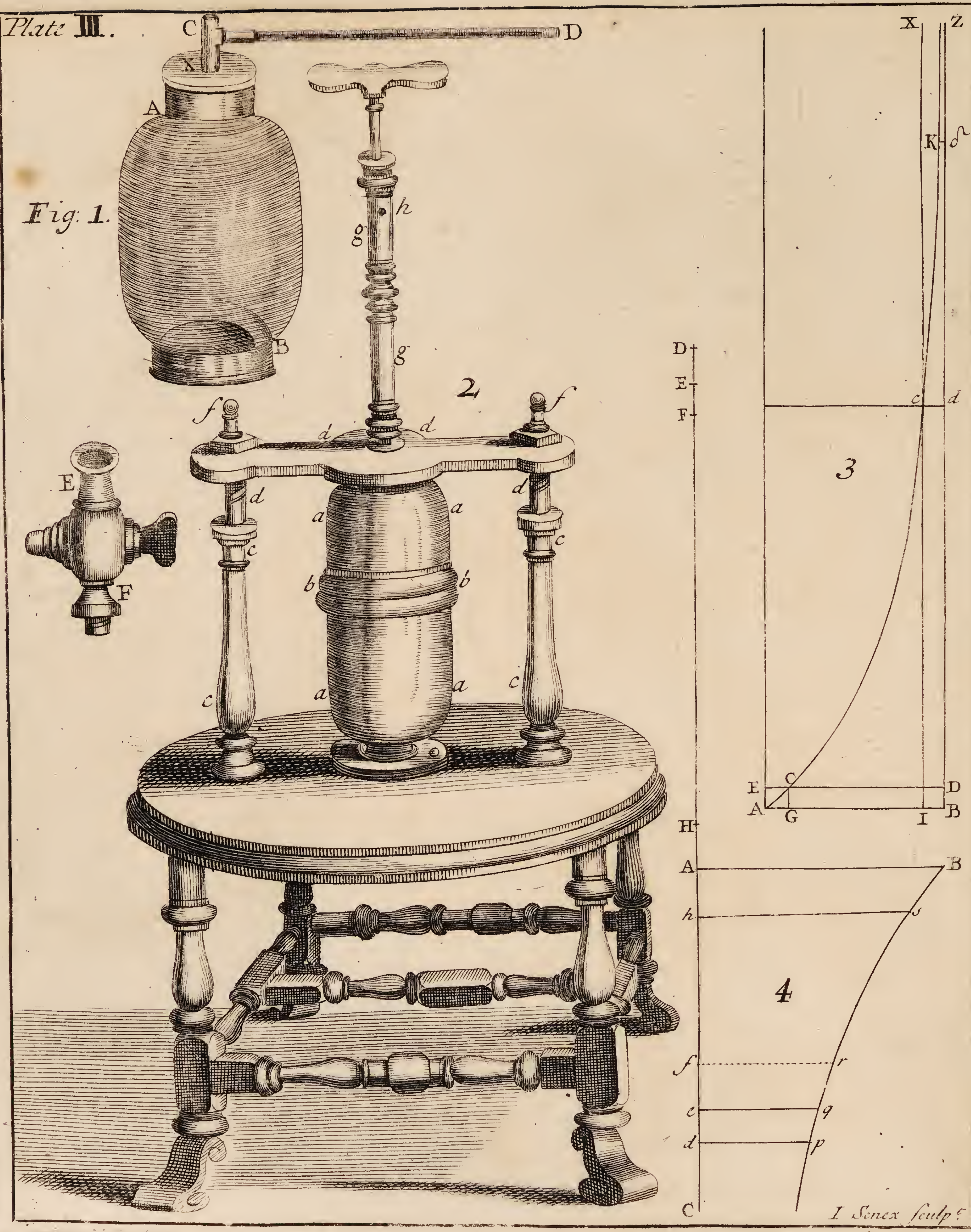
FIGURE I. Is the Air-Pump, with its Receiver and Gage, as ready for Uſe: *aa*, *aa* are two ſtrong hollow Cylindrical Barrels, in which are ſuppos'd to be Suckers, with their Handles *cc*, *cc* notched; into which Notches a Cog-wheel falls, which Cog-wheel moves upon the Axis *f*, when the Engine is put into Motion by the Winch *b b*. *g g*, *g g* are two Cylinders of Wood, fixed to the Frame of the Air-Pump, with Screws at the Top, on which the Nuts *e*, *ee* do run, and preſs down the upper Piece *f f* upon the Tops of the Braſs Barrels, to fix them both at Top and Bottom. *h h* is a Swan-neck'd, or ſmall bended hollow Braſs Pipe, leading from the Top-Plate *i i i i*, or rather from the Braſs hollow Piece above *n n*, which communicates through that Top-Plate with the Cavity of the Receiver. This Pipe is ſcrewed to a bottom Braſs Piece, included in the Box *d d*; which is perforated not only lengthways, but alſo upwards, in three Places: The Middle one for a Communication with this Swan-neck'd Pipe, and at the two Ends through ſmall Cylinders, inſerted into the two Braſs Barrels *aaaa*; and 'tis by this Thteefold Communication, that the Air is pump'd out of the Receiver. *l l l* is the Gage; which is no other than a common Barometer, or Weather-Glaſs; with its Baſon of Mercury *m m*, fix'd to the Engine by a particular Contrivance, and its Index or Boxen Receptacle, with Inches, and its Cork to ſupport that Index upon the Surface of the Mercury, and to riſe and fall with it; for the Exactneſs of meaſuring the Height of the Mercury from that Surface. Only this Barometer is open at the Top, and communicates, as does the Swan-neck'd Pipe, with the Cavity of the Receiver. *n n* is a Stop-cock, that communicates alſo with the Cavity of the Receiver, and either excludes or readmits the Air, as you ſee convenient. *k* is the Bottom of the Receiver, ground true to fit the Braſs Circle below it; to which it is affixed by the Hand at firſt, and afterward by the Preſſure of the Air, with wet Leather inſtead of Cement.

Fig. 2. Is a Barometer Tube, open at the Top H, and included in ſuch a Receiver G B, as gives room for it to ſtand upright, and yet permits the Air to go backward or forward on its Surface, according as you pump the ſame out of or readmit the ſame into that Receiver. And this is done ſo, that the included Air C D, which ſupports the Mercury, by preſſing on the Surface of that in its Baſon E D, is confin'd within. This ſmall Quantity of Air, on the Extraction of that in the Receiver, will, by its Elaſticity, raiſe the Mercury almoſt as high as the uſual Standard: And thereby ſhews, that the Spring of any ſmall Part of common Air preſſes equally with the whole correſpondent Column of the Atmoſphere.

Fig. 3. Is a Contrivance to make an Exploſion of Gunpowder in Vacuo: Where H D is a red hot Iron, ſtanding on its Pedeſtal E, within a Receiver G C; and F is a Cork, made above like a Diſh, to contain the Gunpowder; which by the pulling up and thruſting down a ſtrong Wire, with a Hole like the Eye of a Needle, is in a certain Quantity let fall every time upon the hot Iron; and on the Exploſion produces Flame, and fictitious Air; but very little Sound, by reaſon of the Abſence of the Air that ſhould convey it.

Fig. 4. Is a Syringe, which will ſuck up the Water in the Glaſs C D, when it is in the open Air; but will not do the ſame under the Exhauſted Receiver EF, unleſs for ſo ſmall an Altitude as the remaining Air can ſuſtain.

Plate III.



I. Senex sculp.^t

An Explication of the Third PLATE.

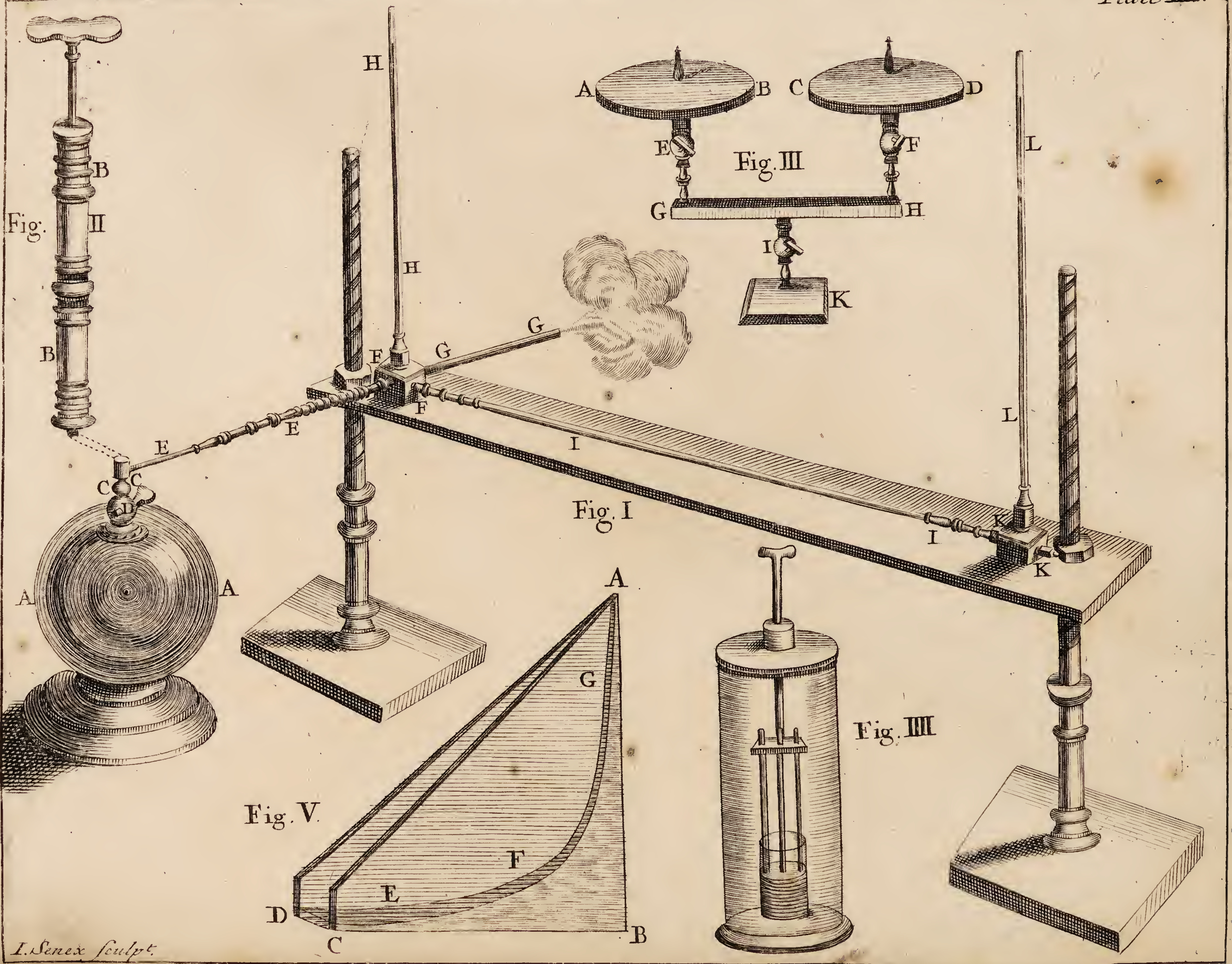
FIGURE 1. Is a large ſtrong Glaſs Receiver, or Condenſer, Arm'd with Braſs Circles at both Ends, and fit to receive and bear the Preſſure of Air conſiderably condens'd, when crouded into it by a Syringe fitted for that Purpoſe. It has alſo annexed to it a Gage C D, to determine the Quantity of the condens'd Air within. This Gage conſiſts of a hollow Tube, Hermetically ſeal'd at D, with another ſmaller included, open towards D, and Hermetically ſeal'd at the other End. In this ſmaller Tube is left a little Quickſilver: This Quickſilver is by the Air at D in the larger Tube, which communicates with the condens'd Air in the Receiver it ſelf, and ſo is of the ſame Denſity with it, crouded inwards towards C every time of the Admiſſion of new Air; and by its whole Length from the End near D, compar'd with its Diſtance from the End near C, it determines the Proportion of the Denſity of the included Air to that of the common Air. *Note*, That the Syringe to be made uſe of with the Receiver, is the ſame with that repreſented in the next Figure, as joined to the condenſing Engine it ſelf; and acts by pulling up the Sucker above the Hole H, for the Admiſſion of a full Cylinder of common Air, and then crouding it down into the Receiver; at the Bottom of this Syringe is a Valve, that hinders what is once crouded in from returning back again, as is neceſſary on all ſuch Occaſions.

Fig. 2. Is the uſual Braſs Condenſer it ſelf, with a Stop-cock E F near it; to be interpoſed between the Syringe and the Receiver upon Occaſion. The Inſtrument, beſides the Frame, is compoſed of a Recipient of Braſs, made of Two Hemiſpheres, or what is equivalent to them, cloſed together by a Ring of wet Leather, to keep in the Air; and becauſe in this Caſe the denſe Air within endeavours forcibly to disjoin theſe Hemiſpheres, they are confin'd down cloſe by a ſtrong Piece of Iron, and Screws belonging thereto. The Syringe already deſcrib'd, is repreſented as join'd to it after the ſame manner that it is when the Air is thereby intruded. This Braſs Recipient will bear Air very much denſer than the foregoing Glaſs one, tho' it being not tranſparent as the other is, cannot be ſo pleaſant, nor ſo well ſhew the Mutations that happen to Animals or other Bodies in condens'd Air as the former.

Fig. 3. Is the Logarithmick Curve A C *c*, with its Ordinates AB, C D, *c d*, K δ repreſenting Abſolute Numbers, and its Abſciſſæ, C G or D B, I *c* or B d and B δ, repreſenting their Logarithms, whoſe famous Property it is, that one Ordinate as A B, is to another Ordinate as C D, or *c d* or K δ, as that unlimited Space between the Curve and Aſymptote above the one, is to that above the other; and whence is deduc'd the Proportion of the Air's Rarity at all Altitudes whatſoever; that at 7 Miles high it is 4 times as rare; at another 7, or 14 Miles, it is 16 times as rare, and ſo for ever, in a Geometrical Proportion of Rarity, compar'd with the Arithmetical Proportion of its Altitude; tho' all this is here upon the Hypotheſis that the Diſtances are not ſo great, that the real Gravity of the Parts be ſenſibly diminiſhed. For in that Caſe,

Fig. 4. Gives the Scheme, which is made uſe of to diſcover the Air's Rareneſs, even at ſuch Diſtances, as imply a conſiderable Alteration in that Gravity; whence it will appear, that the Denſity of the Air is diminiſhed in that Caſe more than 4 times for every 7 Miles of Altitude.

Plate IIII.



I. Senex sculpt.

An Explication of the Fourth PLATE.

FIGURE 1. Is a compound Inſtrument, to ſhew, why in a Storm the Mercury in the Barometer vibrates ſo much, by a parallel Caſe in an Imitation of ſuch a Storm. A A is a large hollow Braſs Sphere, into which by the means of the Syringe in *Fig.* 2. Air is crouded till it is 8 or 10 times as denſe as uſual. H F and L K are Two Barometers, with their Baſons in the Boxes F F, K K, which Boxes communicate by a long hollow Tube I I. E E is a Braſs hollow Tube, to convey the crowded Air near the Surface of one of the Baſons of Quickſilver, which Air paſſes out of that into a larger hollow Pipe G G, and ſo into the open Air. Upon the turning of the Stopcock C to give vent to the condenſed Air, it ruſhes with great Force along the hollow Pipes E E, G G; and as it paſſes not far off the Surface of the Baſon of Quickſilver F F, it cauſes the Mercury in both the Barometers H H, and L L, to deſcend and vibrate ſeveral Inches, as the great Storm made Barometers deſcend and vibrate in Chambers at a diſtance from it.

Fig. 3. Is a Transferrer; containing one common hollow Stem I (here repreſented as ſcrew'd to a ſquare Piece of Wood, and thereby held upright) with its Stopcock I, and its Horizontal Hollow G H with which it communicates. Upon this Horizontal Piece two more hollow Stems are erected, and communicate therewith. Theſe alſo have Stopcocks E and F, and to theſe are ſcrew'd Two Braſs Plates AB and C D, on which Two Recipients may be fix'd, and may communicate with the reſt. By this means the whole Inſtrument may be apply'd to the Air Pump, and one or more of its Recipients exhauſted; and afterward any Factitious or Natural Air may be transferr'd from one Receiver to another, as Occaſion requires: Of which Inſtrument Mr. *Boyle* made great Uſe in his Second Continuation of Experiments.

Fig. 4. Are very ſmall or capillary Glaſs Tubes, of different Bores, let down into Tinged Water, in Vacuo, to ſhew, that by the Attraction of the Glaſs the Water will be elevated, contrary to the ordinary Law of Hydroſtaticks, and that to a conſiderable Height; and what is chiefly remarkable, is, that the Altitude of the Liquid in the Tubes is the ſame in Vacuo as in the open Air, and is always in an exact reciprocal Proportion to the Diameters of their Baſes.

Fig. 5. Is the noble Improvement of the former Experiment by Mr. *Hauksbee*, *Sen.* upon which the Learned Mr. *Ditton* has written a ſmall Treatiſe. It is done by two Glaſs Plains, A C B, A D B, meeting in an Axis at AB; and being about a Tenth of an Inch diſtant at the greateſt Aperture D C. Theſe Plains are Erected in Spirit of Wine, and are like a Series of Tubes of all different Diameters leſs than D C, which muſt therefore elevate the Fluid a little at DC, and higher all the way to B, where the Elevation ought to be Infinite; the Tops of the elevated Columns will form an Hyperbola, E F G, with its Two Aſymptotes, the Surface of the Fluid DCB, and the Line BA. *Note*, That if the Angle at D C be altered, the Bigneſs of the Hyperbola will be alter'd, while its Species remains; but that if the Angle A B C be alter'd, the Species of the Hyperbola will be alter'd alſo, though it will ſtill be a true Hyperbola, and that if the Glaſs be clean, to a ſurprizing Degree of Exactneſs.

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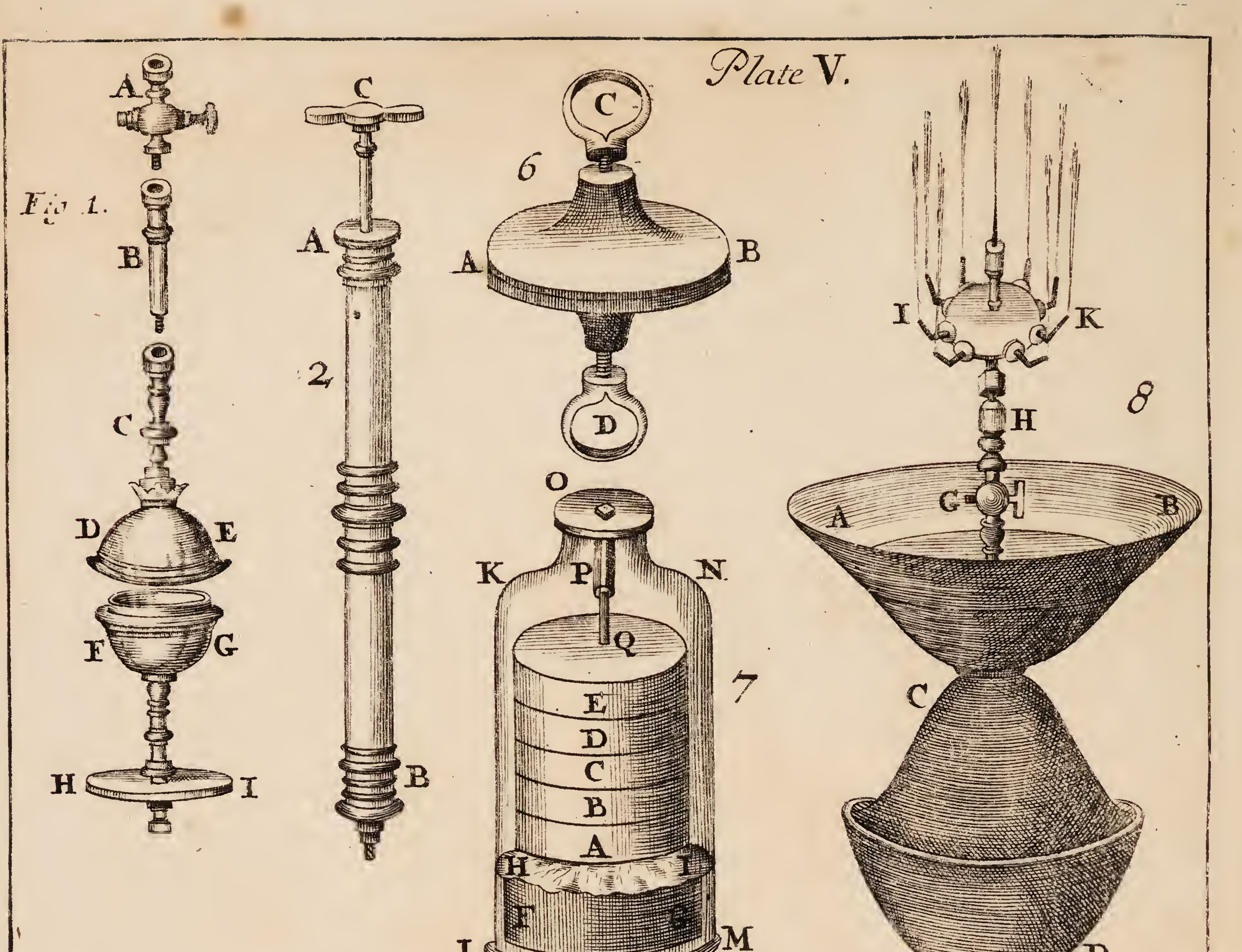
Plate V.



Sutton Nicholls sculp:

An Explication of the Fifth PLATE.

FIGURE 1. Are *Otto Guerick*'s Hemiſpheres, with their ſeveral Screws and Apparatus at large, ſet ſeparately by themſelves. They are deſigned to prove that the Force of the outward Air, when the inward is extracted from between them, is equal to the Weight of a Column of Quickſilver of about 29 Inches and a half: Of Water of about 34 Feet: And of Air to the Top of the Atmoſphere, all preſſing upon the ſame Baſe with the largeſt Circles of thoſe Hemiſpheres.

Fig. 2. Is the Syringe, with its Hole; to be ſcrew'd on to the Top of the Receiver of the next Figure; in order to thruſt Air into it, for the Improvement of the former Experiment; or to ſhew that tho' common Air be left in the Hemiſpheres, yet if that on their outward Surface be made twice or thrice as denſe, they will ſtill ſuſtain an equal, or a double Weight reſpectively, before they are ſeparated.

Fig. 3. Is that Inſtrument included in ſuch a Receiver D B, and that Receiver kept cloſe to its Baſis by a croſs Piece and Screws, as in the Condenſer before: Together with a newly contriv'd Stiliard, to which the upper Hemiſphere is hung; with its fixed Baſe, and its Gage, to meaſure the Degrees of Condenſation of the Air, where by the Proportion of S P to P K, the Weight 50 w. is equivalent to greater Weights, and ſhews how many Pounds are required to ſeparate the Hemiſpheres in all Caſes. If the Diameter be 3 Inches and a half, they will ſuſtain about 150 Pounds; and ſo in all other Proportions.

Fig. 4. Is the Plate which covers the upper Part of the Receiver. And through the Hole C the Piece D E ſlides, which takes hold on the upper Hemiſphere.

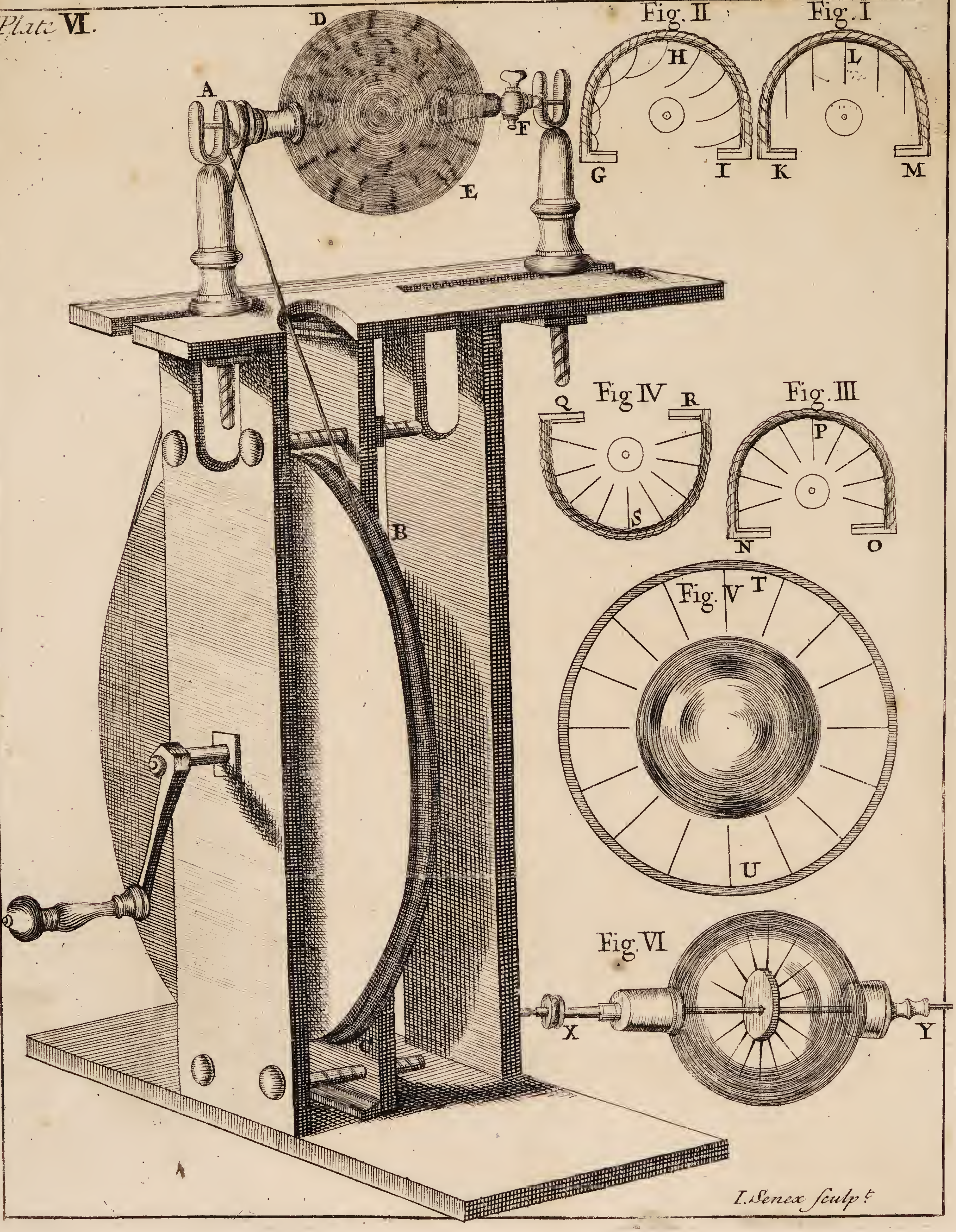
Fig. 5. Shews the Gage of the ſame Inſtrument; this is like that for the Glaſs Condenſer before deſcrib'd, and contains a bended Tube, whoſe open End is in a ſmall Baſin of Mercury; and the other is Hermetically ſeal'd: For this Mercury crowded by the condenſed Air in the Receiver, will croud the Air in the ſmall Tube cloſer in Proportion to its Denſity, and ſo will afford us the Knowledge of the Quantity thereof.

Fig. 6. Is a like Experiment of the Coheſion of poliſhed Plates of Braſs, or of Marble; when the Air is excluded by a little Oil, and an exact Application. This Coheſion may be weighed by the Stiliard, as well as that of the Hemiſpheres; and is equal to the ſame, upon the ſame Baſe; provided a Ring do prevent their ſide or ſliding Motion; and provided the Air can equally be excluded from between the Plates, as between the Hemiſpheres Which laſt yet is almoſt impoſſible to be done.

Fig. 7. Is a Number of great Weights, kept ſteady one over another by an Iron Rod paſſing through them, and preſſing upon a Bladder half blown, plac'd below them: This Bladder, by the Elaſticity of its included Air, gradually elevates all thoſe Weights; as ſoon as by the Extraction of the other Air out of the Receiver, wherein they are all included, its Counterpoiſe is gradually taken away.

Fig. 8. Is a Number of *Jet d'Eaus*, or Fountains, made by condens'd Air, in a large Copper Veſſel C D, preſſing on the Surface of Water at the Bottom of the Veſſel; into which Water a hollow Braſs Pipe is immers'd. For if there be then a Stopcock at G, to open or ſhut the hollow Pipe at Pleaſure; and ſeveral ſmaller Pipes at I K, communicating therewith, turning upon Balls or Joints, and plac'd in Order, we ſhall have a very pleaſant Set of theſe *Jet d'Eaus*, or Fountains; all whoſe Water will be caught by the Baſon AB, which Water may be again let into the Veſſel C D, by unſcrewing the Pillar in the Center of the Baſon.

Plate VI.



I. Senex ſculp^t

An Explication of the Sixth Plate.

THIS Plate is in Reality but one compound Inſtrument or Apparatus, for trying the Electricity of Glaſs, and its Luminouſneſs, when put into Motion, and rubb'd upon to heat it. Wherein B C is a Wheel, with its String A B C. D E is a Sphere of Glaſs, whoſe Air has been drawn out by the Air-Pump: This is turned round by the former Wheel-ſtring at A. F is a Stopcock, whereby the Air is exhauſted, and may be readmitted at Diſcretion.

In *Fig.* 1. K L M is an Arch with Threads of Cruel or Yarn upon it, as they hang about the Glaſs D E, (here repreſented by a ſmaller Circle within the Arch) before it is turned round or heated by rubbing.

Fig. 2. G H I is the ſame with the former; only the Threads are here repreſented as they hang at the Beginning of the turning round of the Globe, before it be heated by Friction; being plainly bent one way, by a Wind ariſing from that Convolution.

Fig. 3. N P O is the ſame; only with the Threads pointing towards the Sphere, or its Center, when the Arch is in an upright Poſture, and ſome of the Threads hang partly downwards, and this upon the Spheres being heated ſufficiently.

Fig. 4. Q S R is the ſame, with its Threads pointing the ſame way, though in a downward Poſture, when ſome of the Threads thereby are forc'd to ſtand erect.

Fig. 5. T U is a Circular Arch, in an horizontal Poſition, when the Threads point towards the ſame Center, in the ſame horizontal Plain.

Fig. 6. Is another Sphere, communicating with the Air, and to be apply'd to the ſame Wheel in the Room of D E, where-into is inſerted an Axis with a Circle affixed to it; at the Edges of which Circle the Threads are placed. Theſe upon the Friction and Heat of the Glaſs extend themſelves outward, and point from the Center to the Circumference, contrary to the former. In both Caſes the Threads, when under the Influence of the Electricity, will be moved by the Finger, even without Contact, nay by the Finger and Breath, even through the Glaſs it ſelf; ſo ſubtle are theſe *Effluvia*. The Light is made when the Air is exhauſted, and diminiſhes as you readmit it. It ſpreads and branches it ſelf inwardly like Lightning, when about half that Air is readmitted. The Colour of that Light is always Purple. It ſpreads at ſome Diſtance, and makes the Edges of a Cravat look a little like the milky Way, by the great Number of Sparkles it emits: Which may alſo be felt by the Fleſh, with a crackling Noiſe that accompanies them. If you alſo ſufficiently rub and heat a large Tube of Glaſs, either ſolid or hollow, it becomes ſtrongly Electrical, even through Glaſs it ſelf; tho' not ſo much througn Muſlin. Other Heat than that by Friction ſignifies nothing. It will attract and repel Leaf Gold, and the like ſmall and light Bodies, after a ſtrange manner, by turns; when once they have been fully repell'd they cannot be made to touch them, till they have been reflected from ſome other Body. If they lye between two Pieces of Wood, laid pretty near, the Electricity fails of its Effect. With other Circumſtances very ſurprizing and unaccountable.

FINIS.